SANTA CLARA VALLEY WATER DISTRICT

Stevens Creek Baseline Fisheries Monitoring 2013 Year 1

Three Creeks Habitat Conservation Plan

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Introduction

The Santa Clara Valley Water District (District) has completed year one of baseline fisheries monitoring in the Stevens Creek watershed focusing on Central California Coast steelhead (CCCS) (*Oncorhynchus mykiss*) for the Three Creeks Habitat Conservation Plan (TCHCP). The TCHCP is the means for the District to apply for, and obtain, a Federal 10(a) (1) (B) Incidental Take Permit for its water supply operations and maintenance activities in the Guadalupe River, Stevens Creek and Coyote Creek watersheds. This permit is to be issued by the National Marine Fisheries Service (NMFS) for CCCS, a listed species under the Federal Endangered Species Act.

Habitat Conservation Plan(s) are required to contain monitoring measures to comply with the Five Point Policy guidance established by the U.S. Department of the Interior and Commerce (NOAA, 2000). Three elements of the Five Points Policy which are pertinent to this report are as follows: monitoring for compliance, effects and effectiveness and adaptive management, which includes methods for addressing uncertainty and monitoring assurance that stated biological goals and objectives are being addressed. This policy guidance provides assurance to the federal agencies who oversee resource management of listed species (i.e. CCCS) that there will be nationwide consistency in development of an incidental take permit application.

Before alternative flow management strategies for steelhead are implemented under the TCHCP, a measurable index of current steelhead status needs to be developed. Developing an index of the current population status will help elucidate succinct, measureable biological goals and objectives while providing a means to measure effects and effectiveness of water operation strategies as well as assist in development of adaptive management planning through the life of the program.

The core monitoring method selected as a basis for determining steelhead production and assessing the District's water operations within the TCHCP watersheds is out-migrant smolt trapping. The freshwater residence time for steelhead is variable and can be affected by a variety of natural and anthropogenic factors, including but not limited to: hydrology, water releases from reservoirs, outfall pumping, urban runoff, and pollution, habitat modification, and recreation, competition, and predation (Moyle, 2002). The response of steelhead populations to changes in freshwater habitat quality will be assessed by measuring smolt production. Estimates of smolt abundance provide a measure of productivity of steelhead populations in freshwater habitats and are an effective means of measuring the aggregate watershed condition (Bradford et al. 1997) (Ketcham et al. 2005).

The results of the out-migrant trapping will be juxtaposed to water operations and corresponding flow. The results of year one fisheries data and water operation information is presented within this water year report as well as additional sampling efforts conducted by the California

Department of Fish and Wildlife (CDFW) 2013. Two additional years of monitoring will be conducted within the Stevens Creek watershed using the methods identified in this report. Upon completion of the three years of smolt capture data and related water operations/hydrology information, TCHCP steelhead management conservation strategies for water operations will be assessed based on study findings and results, then refined, as appropriate.

The data collection efforts for the TCHCP will build upon previous data collection efforts for steelhead in the Stevens Creek watershed which were conducted by Stillwater Science for the Santa Clara Valley Urban Runoff Pollution Prevention Program (Stillwater Science, 2004). The Limiting Factors Analysis (LFA) conducted focused surveys for historical changes to the physical habitat, fish passage barriers, sediment related factors, and water temperature. The geomorphic setting as characterized in the LFA is summarized within this report to provide context to the quality of the freshwater habitat which is being evaluated, but it should be noted that no additional geomorphic data was collected for this analysis. Conclusions and recommendations from the Stillwater Science investigation of 2004 are incorporated into this report.

Several key areas of focus in the priority recommendations from the LFA were included in the monitoring plan and subsequent data analysis for this report and include; smolt trapping to determine smolt size abundance and outmigration timing, a detailed analysis to determine the timing and magnitude of flows necessary for upstream passage by adults and downstream passage by smolts, and an evaluation of the seasonal dryback of the lower reach to determine impacts of flow related barriers on steelhead production.

Watershed Description

The Stevens Creek watershed lies on the northeastern slopes of the Santa Cruz Mountains in Santa Clara County. Stevens Creek originates at an elevation of 2,300 feet where it flows easterly for approximately 8 miles before reaching Stevens Creek Reservoir which resides at an elevation of 554 feet. Downstream of the reservoir, the creek runs northerly though the Cities of Cupertino, Sunnyvale, and Mountain View for 12.4 miles before discharging through Whisman Slough into South San Francisco Bay. One natural tributary, Heney Creek, confluences with Stevens Creek 3.6 miles downstream of the reservoir which has a drainage area of 0.65 miles^2.

The Stevens Creek watershed is approximately 29 miles square in size. However, all flows from the adjacent Permanente Creek watershed are diverted into Stevens Creek via the Permanante Creek diversion channel constructed in 1959 for flood protection, bringing the total drainage area of Stevens Creek downstream of the diversion to 46 square miles (SCVWD, 2007). The Permanente Diversion channel confluence is located 6.4 miles downstream of the Stevens Creek reservoir. While it is unclear in the historic record if and where these two watersheds were ever connected prior to extensive settlement in the Santa Clara Valley, the Permanente Diversion channel connects the two watersheds presently. Therefore, the portion of the Permanente

watershed above the canal confluence is analyzed in this report as an ephemeral tributary of Stevens Creek (Figure 1) (SFEI, 2010).

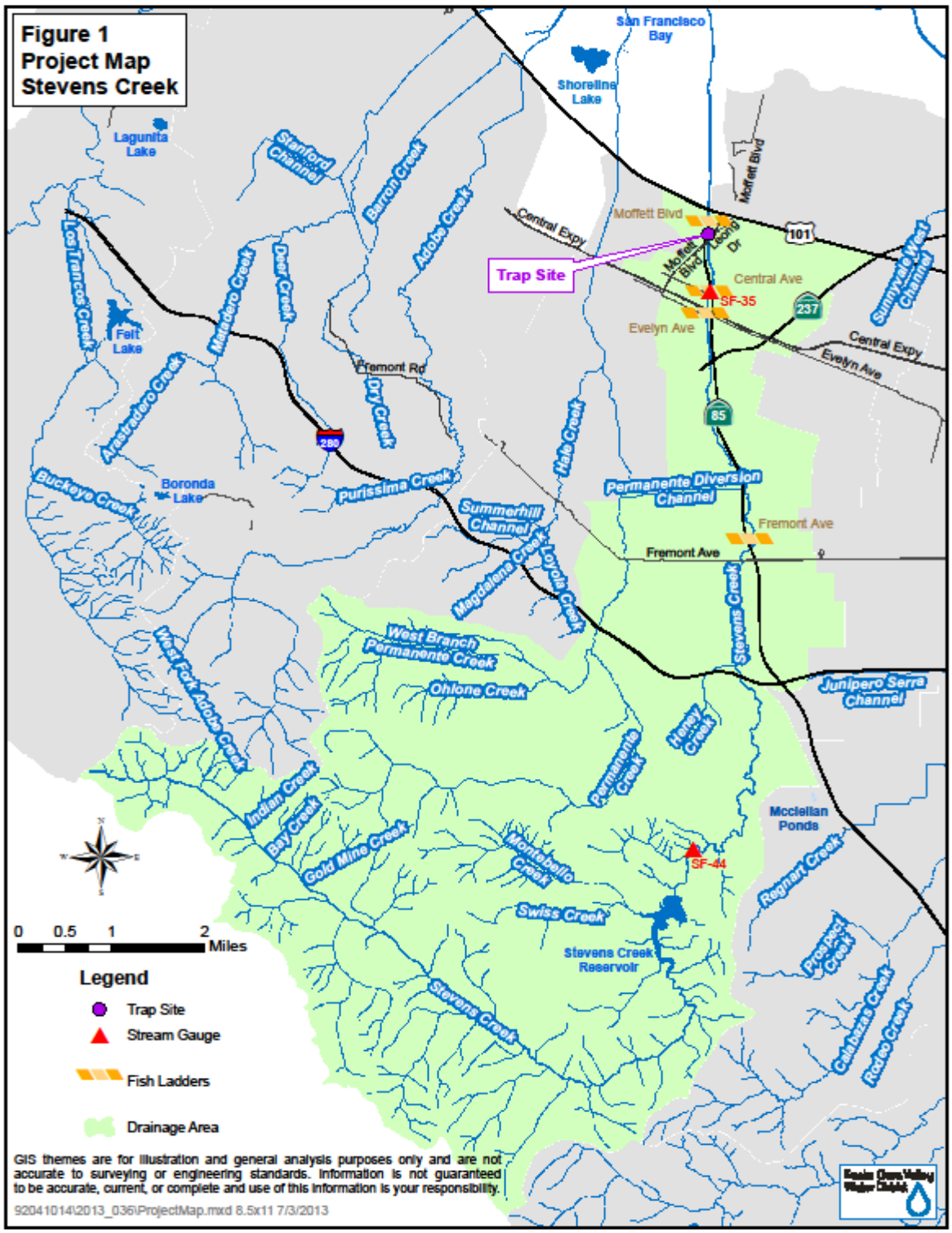
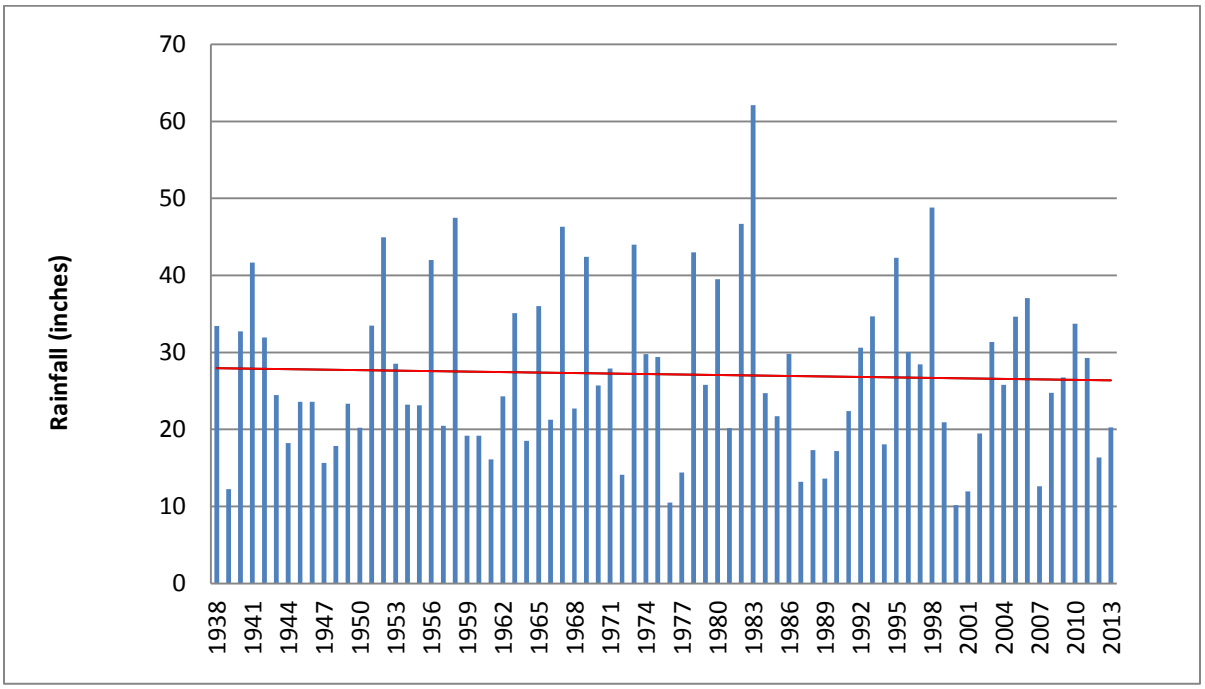


Figure 1. A map of Stevens Creek Watershed including drainage area, fish ladders, stream gauges and trap site location.

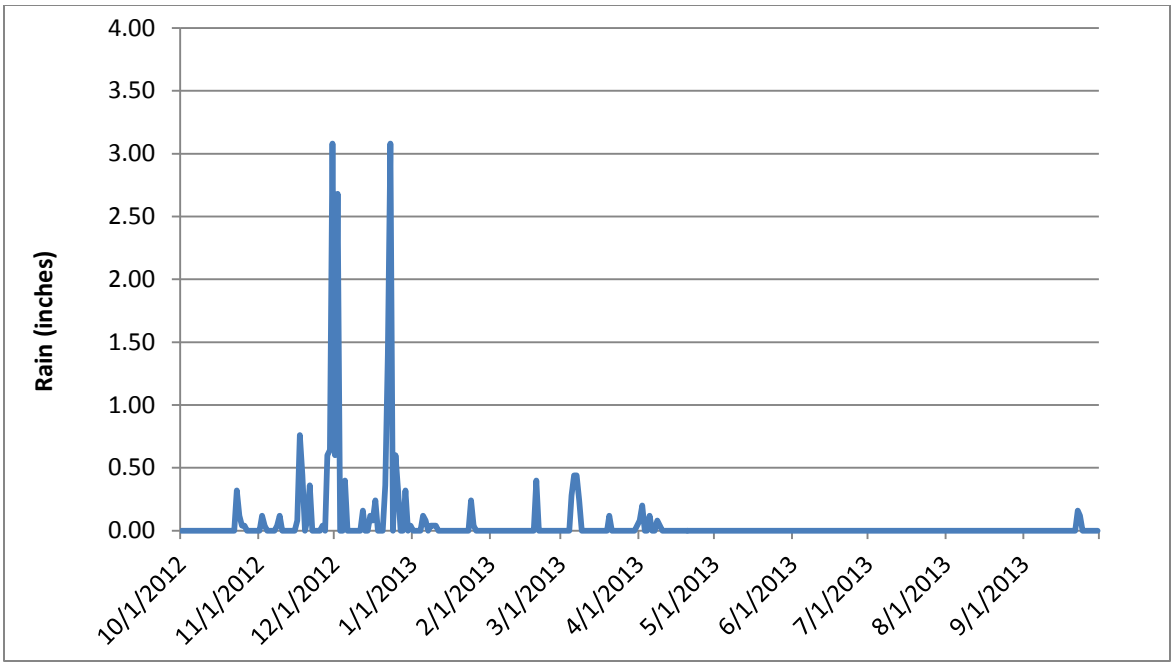
The upper elevations of the watershed are rural and are characterized by moderately dense forests of oak woodlands and steep slopes. The valley floor is marked by moderate to high urbanization which gently slopes towards the San Francisco Bay. Historically, Stevens Creek did not maintain surface connection to the Bay, but sank into an alluvial fan where it recharged the aquifer before it emerged further downstream into wet meadows and willow groves. It is noted in the historic record that even without a well defined channel, the creek was frequently connected by surface water to the San Francisco Bay during high flow events. By the late 1800's a well defined, constructed channel connected Stevens Creek to the Bay (SFEI, 2010).

Hydrology

The mean rainfall year annual precipitation (July 01 to June 30) in the Stevens Creek Watershed varies from a high of approximately 50 inches on the upper slopes of the Santa Cruz Mountains, to a low of approximately 13.5 inches on the valley floor. Typical of Mediterranean climates, the majority of precipitation occurs in the rainy season between November and April (SCVWD, 2007). Annual precipitation totals fluctuates in this watershed from a low of 10.5 inches per rainfall year recorded in 1976 (10.16" in 2000) to a high of 62.1 inches recorded in 1983 (Graph 1). For the first year of monitoring in water year 2013, rainfall was recorded to be 20.28 inches which represents 74.6 percent of average (Graph 2).



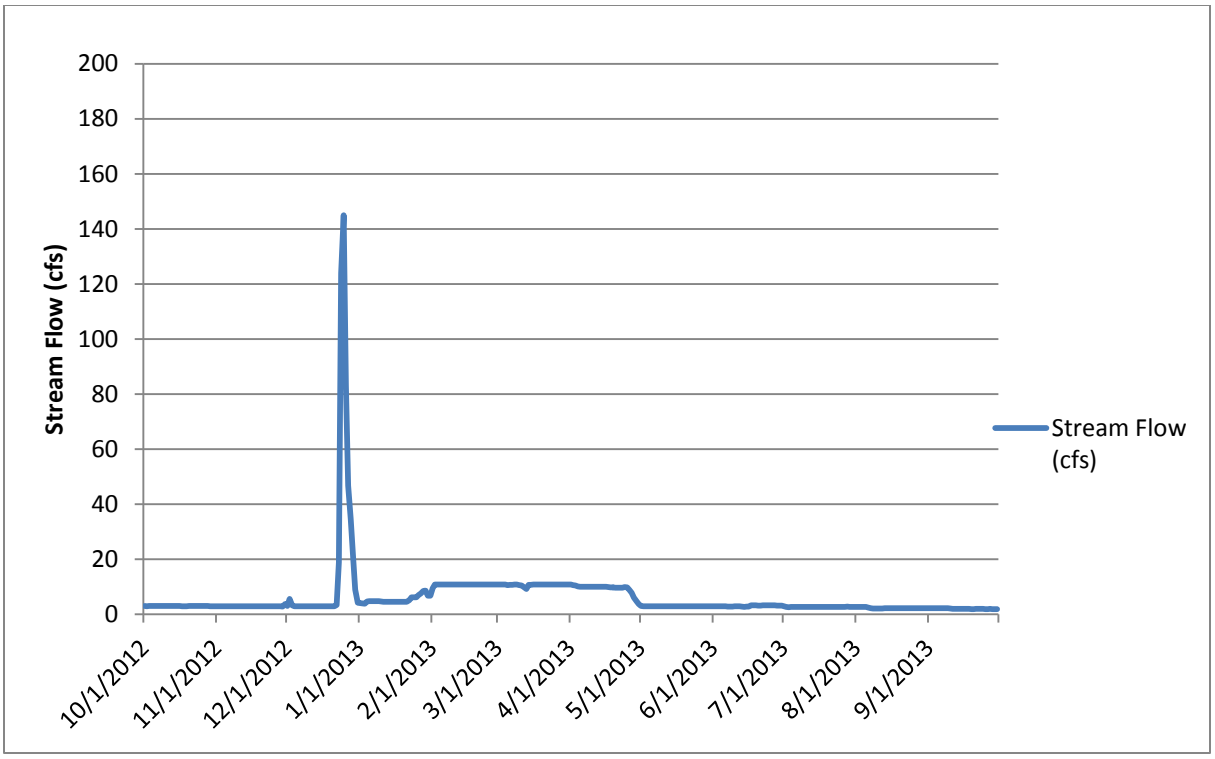
Graph 1Water Year 2013 (July 1- June 30) rainfall records for the Stevens Creek watershed recorded at SCVWD precipitation gauge #6100 (elevation 499 ft) located off Stevens Canyon Road. The red trend line indicates Mean Rainfall Year (27.2 inches) from 1938 to 2013.



Graph 2. Preliminary daily rainfall totals (inches) for water year 2013 (Oct. 01, 2012 -Sept. 30, 2013). Data was obtained from a SCVWD ALERT precipitation gauge #6100 (elevation 499 ft) located off Stevens Canyon Road.

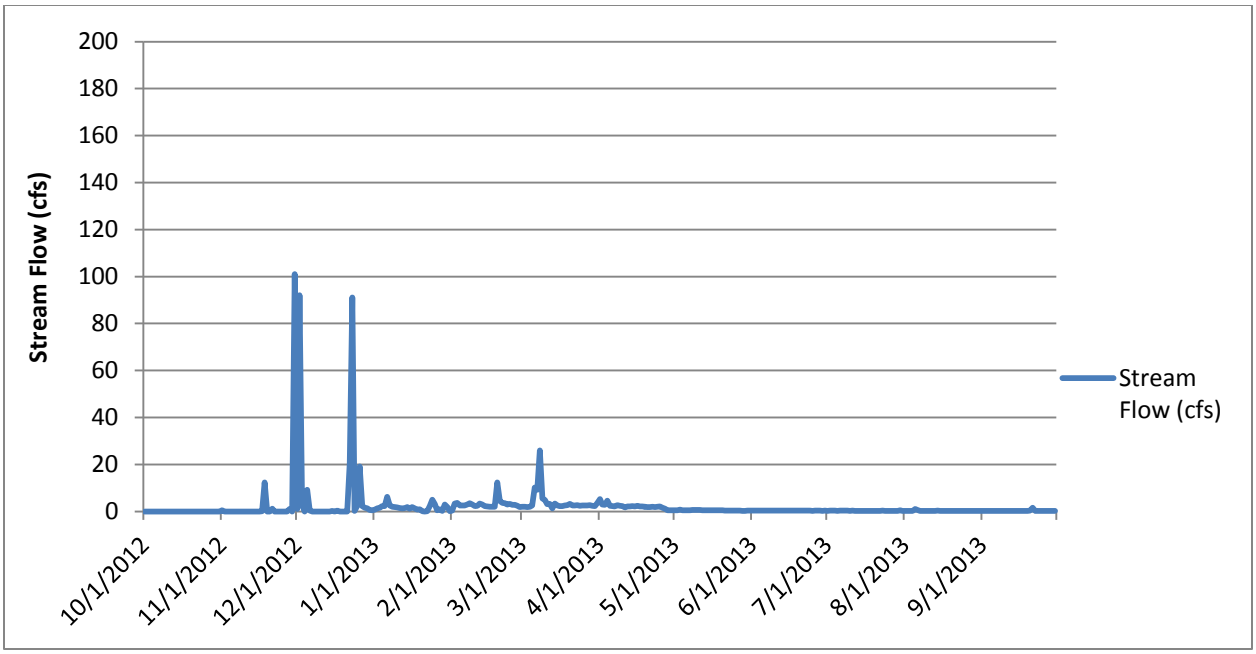
Stevens Creek is perennial in its headwaters for approximately 8 miles before it drains to Stevens Creek Reservoir. The reservoir, constructed in 1935, has a capacity of 3,138 acre feet with a surface area of 91 acres. Stream flow downstream of the reservoir is attenuated and controlled by releases from the reservoir but can be characterized as perennial for 5.7 miles to approximately Fremont Avenue in most years. The stream then dries seasonally and is ephemeral in the middle reaches from approximately Fremont Avenue to downstream of Central Avenue, for approximately 2 miles. Accreted flow from groundwater emerges downstream of Central Avenue which then keeps the stream perennial again until the confluence point with the South San Francisco Bay. The dryback area is consistent with the historic accounts of watershed morphology prior to extensive settlement and water management (SFEI, 2010). The size of the dryback area will fluctuate depending on the annual hydrologic cycle and reservoir operations and local groundwater pumping.

Two District stream gages were utilized to monitor surface flow for this study. Gauge station 44, with a drainage area of 18 mi^2, located 0.6 miles downstream of Steven Creek Reservoir, represents flow releases from the reservoir and is located in the perennial reach of creek. For water year 2013, the hydrograph at gauge station 44, flow was recorded at ~~read~~ approximately 2-3 cubic feet per second (cfs) from October 1, 2012 to December 21, 2012. Base flows increased from January, 2013 to April, 2013 from 4-11 cfs until March 1, 2013 where flows were again reduced to approximately 2-3 cfs for the duration of the water year (Graph 3).

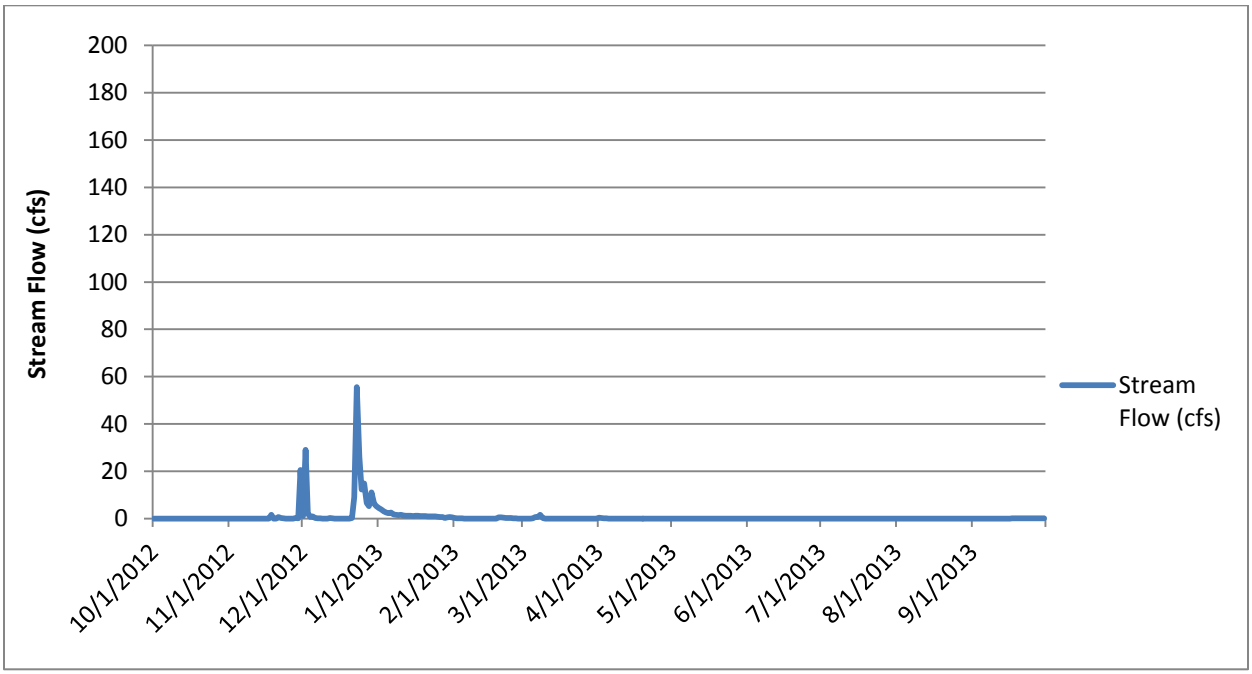


Graph 3. Average daily streamflow (cfs) measured at District operated stream gauge 44 located 0.6 miles downstream of Stevens Creek Reservoir.

The second gauge station on the mainstem of Stevens Creek is gauge station 35, with a drainage area of 24.5 mi^2 located 8.8 miles downstream of the reservoir and resides adjacent to the Central Avenue fish ladder. This gauge is located in the ephemeral middle reach and represents the drainage area downstream of the reservoir which includes two tributaries, Heney Creek, Permanente Diversion channel, and numerous storm drains. (Figure 1). For water year 2013, base flows ranged from approximately 0-1 cfs from October 1, to November 17, 2012. After that period, response to rainfall, flows ranged from approximately 0-101 cfs until January 1, 2013. The middle reaches of Stevens Creek remained wet from January, 2013 through April, 2013 with average daily flows ranging from approximately 1-3 cfs and included several smaller February and March rainfall events which temporarily raised stream flow to approximately 4-26 cfs based on stream gage number 35. Stream flow receded at the end of April to less than 1 cfs where it remained through the conclusion of the water year (Graphs 4 and 5).



Graph 4. Average daily stream flow(cfs) measured at District streamgage 35 located 8.8 miles downstream of Stevens Creek reservoir.



Graph 5. Average daily flow (cfs) at District stream gage 32.1, located on Permanente Creek immediately upstream of diversion channel, measures flow contributions to Stevens Creek from the upper portions of the adjacent Permanente watershed.

Numerous outfalls, approximately 46, contribute to surface flow downstream of Stevens Creek Reservoir-(Figure 2) (SCVWD, 2013). One outfall observed during the course of this study, downstream of the Evelyn Avenue Bridge, contributed significant amounts of flow to the stream (Photograph 1). Discharge, temperature, and conductivity was measured immediately downstream of the outfall to estimate quantity and origin of the water coming from the outfall. The drainage area of this outfall and source of water is unknown, but it is presumed to be coming from a groundwater pumping operation thus owing to the low temperature of the water and higher conductivity.



Photograph 1. A culvert located 50 feet downstream of the Evelyn Avenue Bridge contributing surface water flow to Stevens Creek.

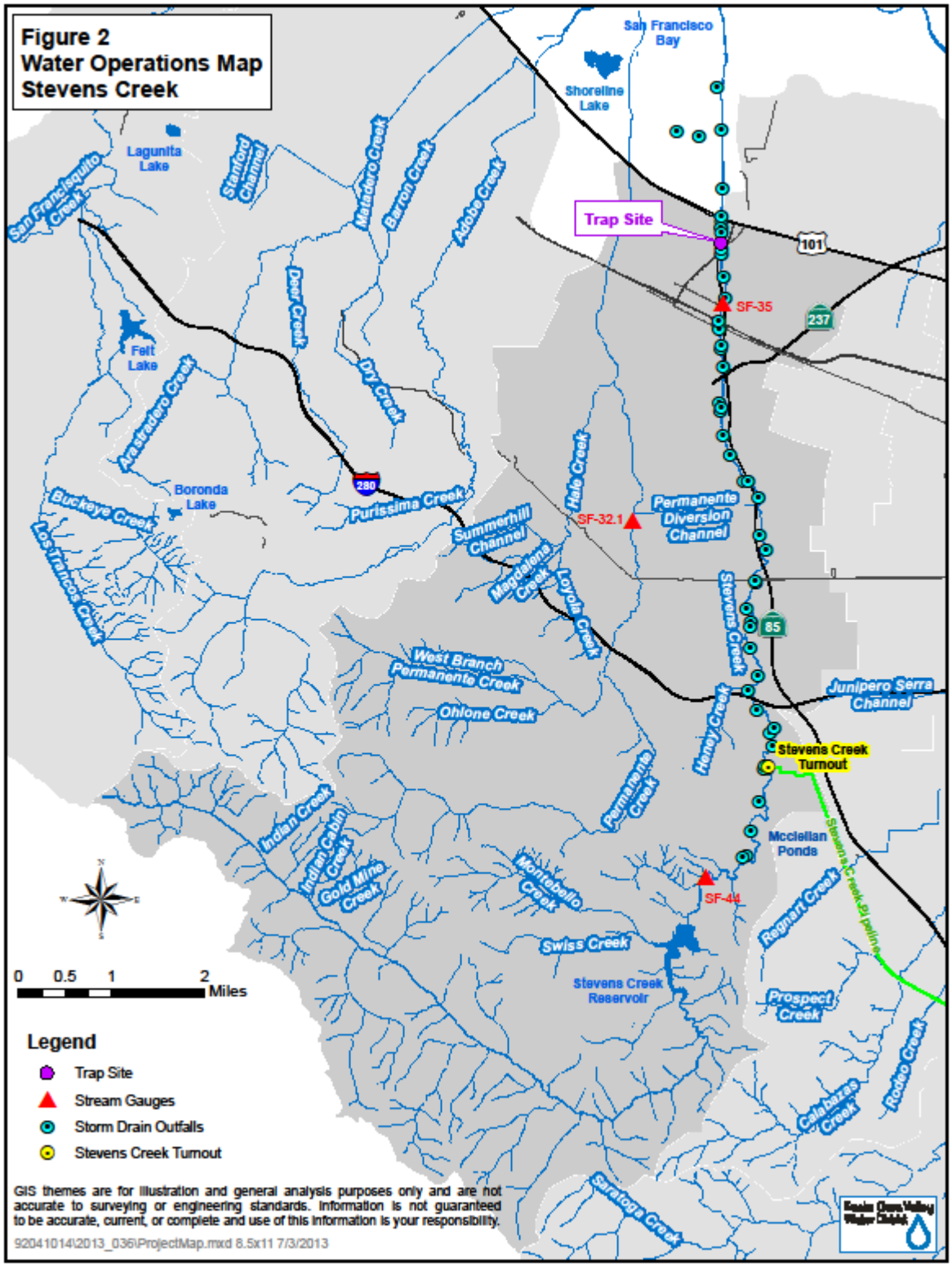
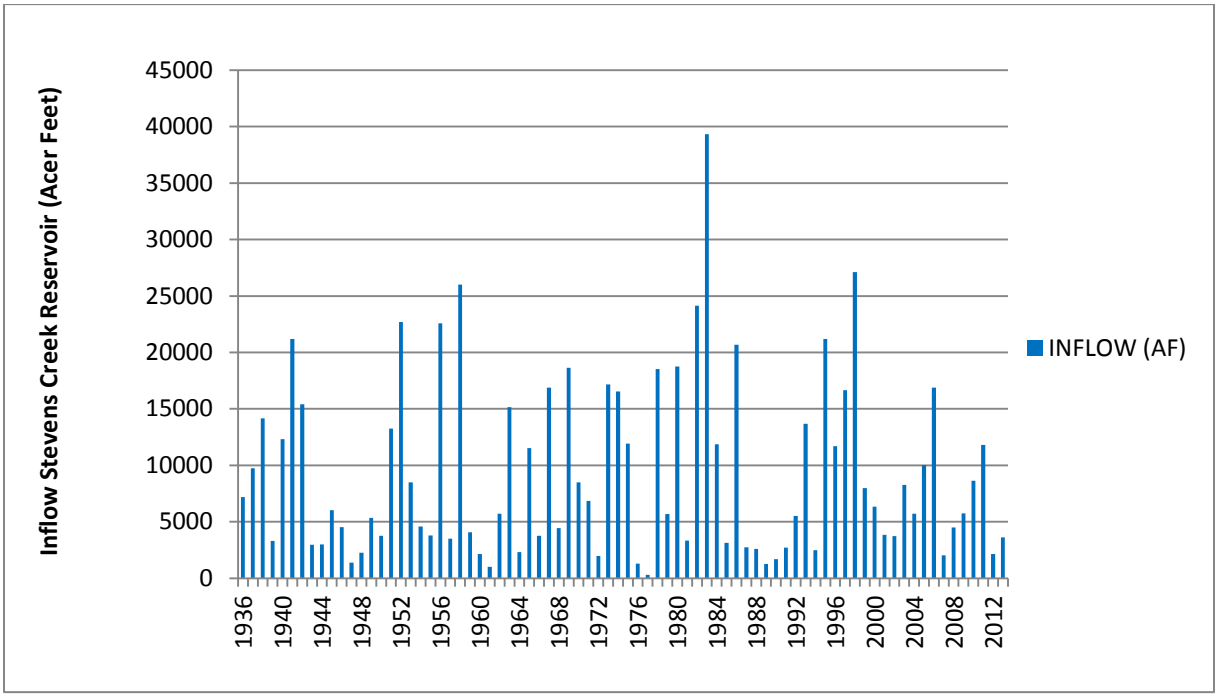


Figure 2. Water Operations map depicting Stevens Creek Reservoir, Stevens Creek Turnout, storm drain outfalls, Permanente Diversion Canal, stream gauges, and trap site location.

Water Supply Operations

Stevens Creek Reservoir diverts water from upper Stevens Creek and stores local runoff for release downstream. Releases from the reservoir are made to provide local water supply and to prevent or reduce the potential for flooding. District staff operates Stevens Creek Reservoir to enhance on-channel groundwater recharge throughout the year. Largely, stored water is released in the summer and fall, so that by November 1, the reservoir has available capacity to capture runoff during the next rainy season. Flood releases are made during the rainy season to create available storage to capture additional runoff from storm events.

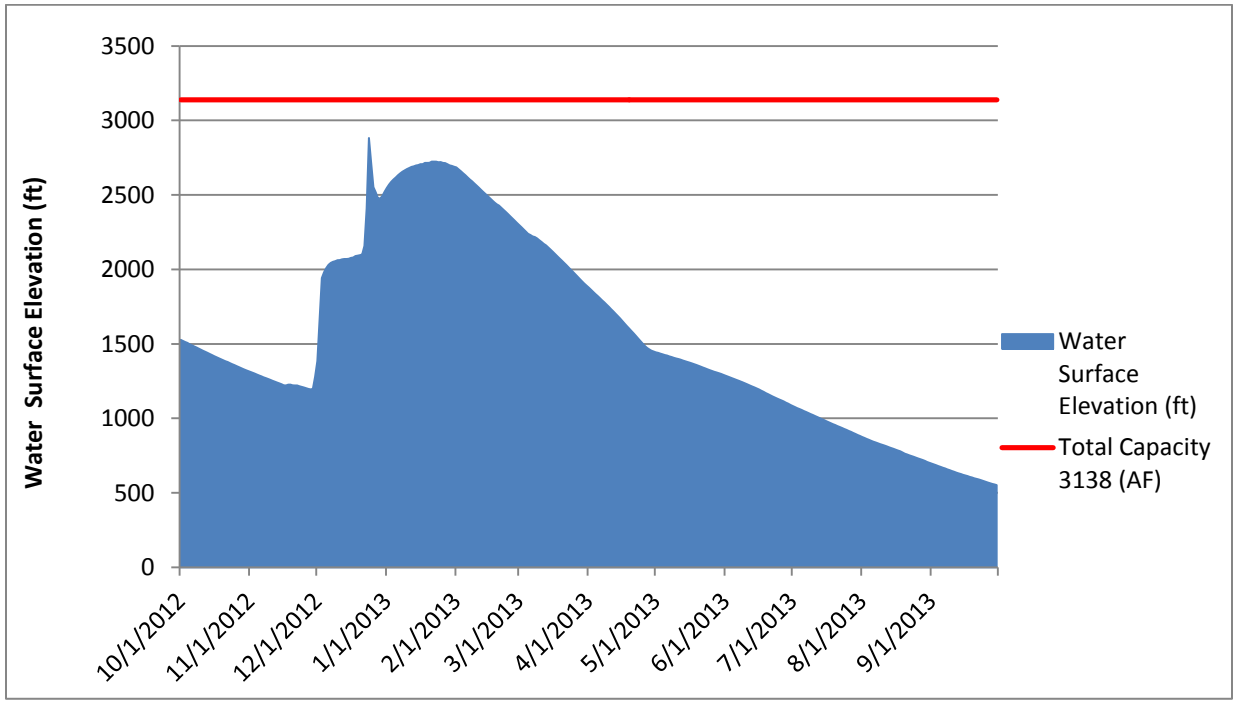
The District holds license to appropriate 4,000 acre-feet per year in the reservoir from December 1 to April 30. During the winter season, water is captured in excess to maximize storage by April 30. When there is sufficient winter storage, the District makes releases from the reservoir to maintain fisheries habitat such that in-channel flows continue to San Francisco Bay. During the summer season, storage is released to meet groundwater recharge needs and to provide adequate carry-over for the next year. On May 1, releases are reduced for the summer period to maintain flows throughout the recharge zone. The recharge zone extends from the dam, to approximately Fremont Avenue (Figure 1).



Graph 6. Calculated Stevens Creek Reservoir inflow (acre feet) for a period of record which began in 1935, after completion of construction to 2013

A probability analysis is conducted for reservoir storage based on rainfall records and inflow into the reservoir (Graph 6). Exceedance probability values are calculated annually and wet years are defined when 10% of the inflows will be exceeded in the defined time period (i.e. 1935-2013) where as a dry year

is defined as 90% of the inflows will be exceeded within a time period (i.e. 1935-2013) (Graph 6). In more simplistic terms, a dry year occurs when 90% of the time inflows into the reservoir are greater than that particular year. For water year 2013, the exceedance probability for Stevens Creek Reservoir was calculated at 72%. There are many factors that influence runoff such as rainfall characteristics, infiltration capacity, vegetation, slope, and catchment size. However, the exceedance probability calculated for water year 2013 demonstrates that this water year was below median and dry even though the rainfall totals were above average. Water surface elevation within the reservoir for this water year did not reach total capacity (Graph 7).



Graph 7. Stevens Creek Reservoir Storage (acre feet for water year 2013).

The District does not own or operate diversions on Stevens Creek downstream of the dam. However, water users, who maintain water rights downstream of the reservoir, may extract flow from Stevens Creek. In addition to releases from the reservoir, the District intermittently provides flow in Stevens Creek from the Stevens Creek Pipeline with local or imported water. The turnout for this pipeline is located 2.2 miles downstream of the reservoir and is operated as a groundwater recharge facility (Figure 2). The turnout was last operated in the spring of 2007 to provide enough water to replenish the aquifer while maintaining reservoir capacity to ensure there was enough water throughout the summer to keep the stream perennial downstream of the reservoir. The turnout was operated again in October, 2013 to augment stream flows in this critically dry water year to preserve the typical wetted reach of stream.

Geomorphic Setting

The LFA, published in 2004, details the geomorphic setting of Stevens Creek within the 12.4 miles of stream below the reservoir to San Francisco Bay as having four significant, distinct reaches: 1) Upper, 2) Transition, 3) Middle and, 4) Lower (Figure 3). The 12.4 mile reach is generally characterized as single-thread planform which is dominated by riffle-pool sequence with occasional plane-bed morphology. The channel gradient below the reservoir ranges from >0.2 for 0.06 miles, but is predominately flat, 0.001-0.02 for 9.5 miles, as it progresses further downstream towards the bay. The median bed grain size also generally decreases in size from the dam to the bay and recent (i.e. decadal) channel incision is prevalent downstream of the reservoir.

The "Upper" reach is defined as the first two miles of stream downstream of Stevens Creek reservoir. The first mile downstream of the dam has a well developed flood plain, intact dense riparian vegetation, high sinuosity with a greater frequency of point and lateral bars (compared to lower reaches), bed material which is comprised primarily of sand, gravel interspersed with subangular cobble, and limited anthropogenic disturbance. The second mile in the Upper reach has similar morphological characteristics, except to note that golf courses, parks, and low density residential housing are found adjacent to the creek in this area. Large woody debris is prevalent within the first two miles and the active stream is on average 4-6 feet below the adjacent land indicating moderate incision.

The "Transition" reach is defined as the point from river mile 2, downstream of the reservoir to stream mile 4.3. The riparian corridor in this reach is narrower with reduced sinuosity, with no connectivity to the floodplain which owing to the previously described channel incision is on average, 12-15 feet below the surrounding valley surface. The stream banks in this reach have a high percentage of armor (i.e. concrete, walls, rubble) to protect residential homes which are immediately adjacent to the stream course. Grain size is similar to that which was described in the Upper reach except to note there is a substantial amount of concrete, rubble, and rip rap which were used to armor the banks left within the stream. The channel incision in this reach has lead to unstable, collapsing stream banks with undercut exposed root wads. The downstream end of this reach is noted as having several small 2-4 foot concrete weirs. Heney Creek confluences at river mile 3.6 in the Transition reach.

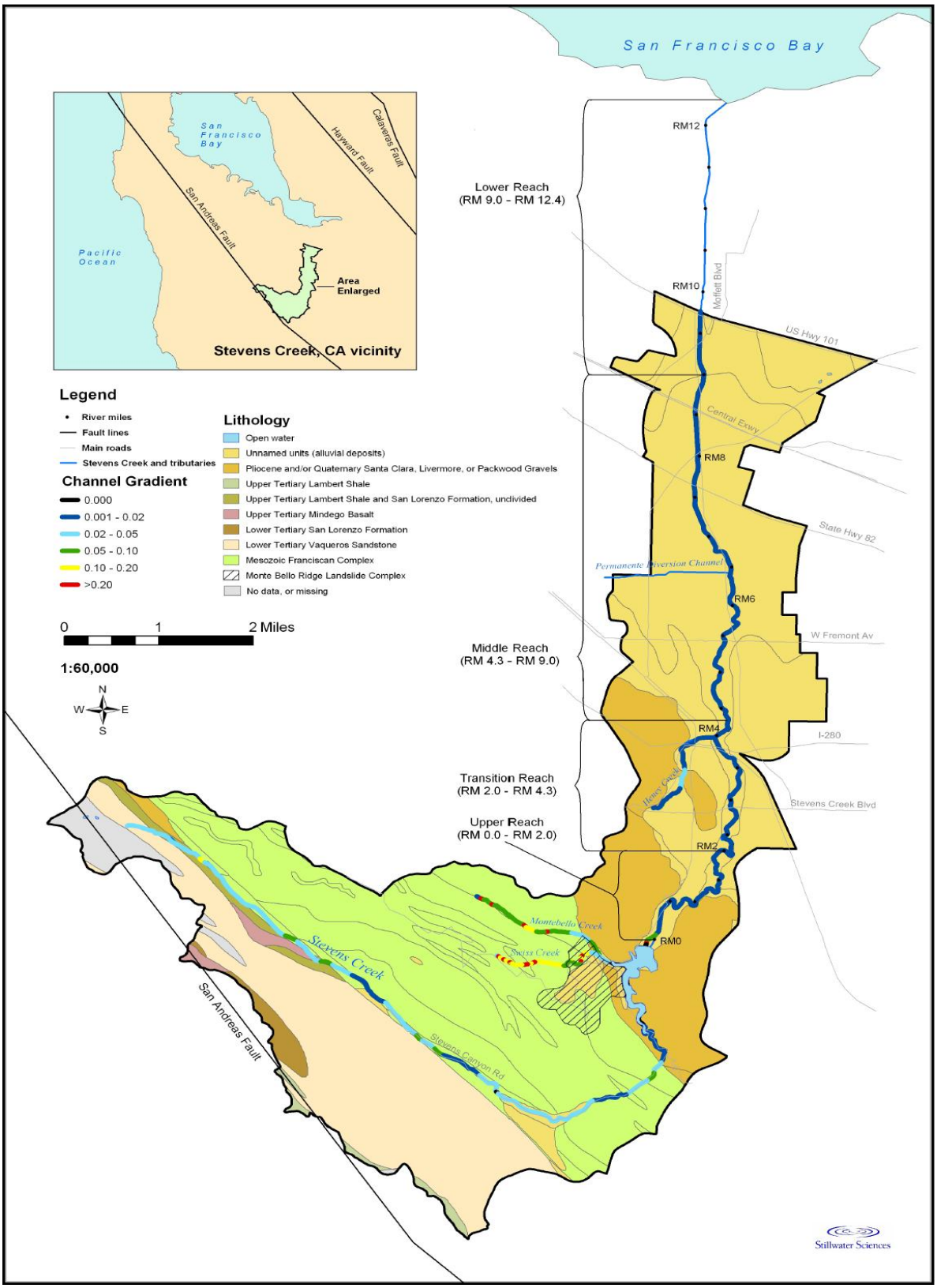


Figure 3. Watershed map depicting the geomorphic setting for Stevens Creek downstream of the reservoir to San Francisco Bay (Stillwater Science, 2004).

The "Middle" reach is delineated as starting at 4.3 miles downstream of the reservoir. This reach has a narrow riparian corridor, is deeply incised (12-25 feet below the valley) with frequent concrete gradient control structures, few lateral and point bars, and long terraces of clay, silt, sand and gravel. The channel bed consists of a thin layer of well mixed sediment from silt to small cobble. Portions of this reach are sporadically confined with a concrete channel as the result of the numerous roads and freeway overpasses. The Permanente Diversion Channel confluences in this reach as well as many storm drains and drainage ditches.

The "Lower" reach is described as starting at river mile 9.0 downstream of the reservoir to 12.4 miles downstream where Stevens Creek confluences with San Francisco Bay. The valley widens here allowing for more lateral movement and silts and clays are prevalent in this reach as the creek transitions to tidal, mud deposits on the creek margin are apparent as well as the prevalence of halophytic vegetation. A mid-channel island bifurcates the stream in the last mile of this reach and channel slope gradually decreases through this reach as it discharges to the bay. District staff periodically (5-8 years) removes sediment from this reach to maintain capacity for flood flows which has localized effects to the geomorphology.

Steelhead Life History

Steelhead/rainbow trout (*Oncorhynchus mykiss*) belong to the family Salmonidae which includes all salmon, trout, and chars. Steelhead are the anadromous form of rainbow trout, a salmonid species native to western North America and the Pacific Coast of Asia. The term anadromous refers to fish species born in the stream that migrate to the ocean for their adult phase. Steelhead are similar to some Pacific salmon in their life cycle and ecological requirements. They are born in fresh water streams, where they spend their first 1-3 years of life. They then emigrate to the ocean where most of their growth occurs. After spending between one to four growing seasons in the ocean, steelhead return to their native fresh water stream to spawn. Unlike Pacific salmon, steelhead do not necessarily die after spawning and are able to spawn more than once.

In California, most steelhead spawn from December through April in small streams and tributaries where cool, well oxygenated water is available year round. The female selects a site with gravel substrate where there is good flow through the gravel then digs a nest, called a redd, and deposits eggs, which the male then fertilizes. The eggs are covered by gravels and cobbles when the female excavates substrate just upstream.

The length of time it takes for eggs to hatch is heavily dependent on water temperature. The optimal temperature for egg incubation is between 7-10° C (44-50° F) and eggs hatch sooner in warmer water, but the young fish are smaller and generally have lower survival rates. After hatching, the developing steelhead will remain in the gravel for another four to six weeks.

During this time, they are called alevins and obtain nutrients from a yolk sack attached to their body. When they emerge from the gravel, they are called fry, and are able to catch their own food.

Newly emerged fry move to shallow, protected areas of the stream, usually in the stream margins. They establish feeding areas which they defend. Most juveniles can be found in riffles, although larger ones will move to pools or deep runs (McEwan and Jackson 1996).

After residing in freshwater from 1-3 years, some steelhead/rainbow trout will smolt, a physiological transformation preparing them for ocean survival. Growth rates of steelhead in freshwater is highly variable. In small California streams with low summer flows, steelhead usually measure 5-9 cm fork length (FL) (≈ 2-3.5 inches (IN)) at the end of their first summer and 10-16 cm FL (≈ 4-6 IN) at the end of their second summer. If summer flows are relatively high and food is abundant, steelhead may grow to 10-20 cm FL (≈ 4-8 IN) in their first year (Moyle 2002). After smolting, based on past available trapping data, steelhead migrate downstream from South San Francisco Bay streams typically from March through mid-June to mature in salt water (SCVWD, 2005).

Adult steelhead enter streams to spawn during winter flows that allow passage through lower stream reaches, in South San Francisco Bay, this means enough flow to "float fish" without stream velocities being too high to prevent sustained swimming. Steelhead have a well developed homing ability and usually spawn in the same stream and area in which they had lived as fry. This means that races and runs of trout are adapted to local conditions (Moyle, 2002). In South Bay streams, this implies that steelhead can persist when water temperatures are relatively high as long as food is abundant (Smith, 1982). Also, since adult steelhead can survive more than one spawn, can over summer or delay migrating into freshwater to spawn, this flexible life history strategy is adapted to the semi-arid Mediterranean climate conditions found in South San Francisco Bay streams.

METHODS

Out-migrant Weir Trap

The out-migrant trap was installed, by District biological staff on March 12, 2013 and was operated continuously until May 23, 2013 when it was removed for the season. The trap was located in Stevens Creek downstream of Moffett Boulevard, 10 miles downstream of Stevens Creek reservoir, and 2.4 miles upstream of San Francisco Bay, in the Lower geomorphic reach of the stream (Figure 1). The trap fyke netting was made of 'Delta' mesh nylon with 1/8 inch mesh size. The fyke net opening measured 10 feet wide by 4 feet high and the 28 foot long net tapered down to 2 tandem wooden trap boxes (Photograph 2). The boxes were finely screened on the sides to allow water to flow through. Additionally, the boxes were internally fit with baffles and

a funnel to protect captured fish from high velocity flow, debris, and reduce the ability to escape. To funnel the fish to the opening of the fyke net, sandbags filled with stream substrate were placed on both sides of the trap opening. On one side of the trap, a gap was left to allow adult steelhead upstream passage past the out-migrant trap (Photograph 3). Three debris baffles were installed upstream of the trap to minimize debris. The baffles were finely screened to avoid entrapment of fish and were staggered from the right and left bank extending to mid-channel and spaced 10 feet apart to not impede fish passage.

The trap was checked by a crew of 3-5 persons and serviced daily during morning hours. All fish were identified, enumerated, measured to fork length and disposition recorded. Steelhead captured were handled wearing wool gloves to minimize harm to the fish's protective mucous surface. Fish captured in the trap were released downstream of the trap site. All steelhead smolts and a sub-sample of young-of-year (YOY) were measured to fork-length.

Dryback Occurrence

On a 24 hr./7 day a week basis, automatic reporting ALERT radio stream gauges assist District Water Operations staff monitor daily flow extent on Stevens Creek which corresponds to reservoir releases. This information was entered into a spreadsheet for each daily ocular observation. The connectivity to the upstream portions of Stevens Creek and San Francisco Bay is summarized in this report with emphasis on steelhead migration season. Water year 2013 is summarized in the results along with the two previous water years 2011 and 2012. The corresponding age of steelhead is summarized in Appendix A.



Photograph 2. Side view of out-migrant weir trap located in Stevens Creek, March 12, 2013.



Photograph 3. Front view of out-migrant weir trap located in Stevens Creek, March 12, 2013.

Trap Efficiency Analysis

To satisfy a requirement for the National Marine Fisheries Service's (NMFS) Federal 10(a)(1)(A) scientific research permit, a minimum of 20 steelhead smolts were to be marked and released up stream of the out-migrant trap for recapture. Due to the low number of steelhead captures in the trap in 2013, no smolts initially captured in the trap were marked and released upstream for recapture.

However, four steelhead smolts were captured in the pools of the Central Avenue fishway (Photograph 4). The fish were isolated in the ladder pools due to dryback conditions. After consultation with the NMFS and California Department of Fish and Wildlife (CDFW) on May 2, 2013, a decision was made to relocate steelhead smolts and young of year (YOY) from the fishway and use the captured smolts for a trap efficiency exercise. On May 3, 2013, under on-site observation and direction from CDFW, four steelhead smolts were initially captured in the ladder pools by electrofishing. These fish were allowed to recover in aerated coolers where they were subsequently transported downstream to Moffett Boulevard. The fish were measured to fork length and scales taken for recapture identification and age analysis purposes. These fish were then released approximately 1500 feet upstream of the out-migrant trap.



Photograph 4. Central Avenue Fish Ladder on Stevens Creek located in the middle reaches of stream, 8.8 miles downstream of Stevens Creek Reservoir (Figure 1).

Scale Analysis

Scale samples were taken from five steelhead smolts ranging in size of 175-215 mm fork length for age analysis during trapping operations. Scales were removed by scraping from the front of the fish toward the tail with a sterile scalpel. All of the scales were collected from the same area and side of each fish, just below the dorsal fin on the left side. Each sample was placed in an individual coin envelope and labeled with species, sample location, date and fork length. The scalpels used to take scales were cleaned after each sample collected for subsequent use on other fish. The scales were cleaned and mounted between glass slides where they were photographed under a compound microscope (i.e. 200X) with high magnification and resolution. The photographs were sent to Dr. Jerry Smith at San Jose State University for age analysis. Annuli form regularly on cylcloid scales. When growth slows or ceases in the winter, these annuli become crowded or begin to form incompletely. When the growth resumes in the spring the annuli grow around or "cut over" the incomplete annuli (Murphy, 1996). The cycloid scales were analyzed by counting the circuli and the characteristic "cutting over" after growth resumes in the spring and extrapolating the age.

Spawning Surveys

Two adult steelhead were observed and photographed upstream of the Central Avenue fish ladder by a District hydrographer servicing stream gauge station 35 on March 11, 2013 (Photograph 5). The observation was reported to District biologists responsible for trapping operations at Moffett Boulevard which subsequently lead to daily observations for adult fish and two redd surveys in the lower sections of Stevens Creek. The observation of the adult steelhead in the lower end of the watershed also lead to a

quantitative evaluation and instream remediation at a suspected passage impediment for migrating fish at the Evelyn Street Bridge.

During the trapping period, two spawning surveys were conducted. The surveys were performed on March 16 and March 19, 2013. The surveys were conducted by wading in-stream from the trap site at Moffett Boulevard to Evelyn Avenue Bridge where the stream flow became discontinuous. Observations for steelhead redds were made throughout the stream width with particular attention to preferred sites such as gravel beds at the tail end of pools or the heads of riffles (Shapovalov and Taft, 1954). However, steelhead in South San Francisco Bay streams will spawn in areas that are far from typical. This means the best available habitat is utilized. An example of an atypical spawning site would be an area less than 2 meters squared (≈ 6 x 6 feet) (Oregon Department of Fish and Wildlife, 2013 Consideration was given to best available habitat usage (i.e. areas less than 2 meters squared) for the fish as they did not have access to the upper portions of Stevens Creek watershed past the Evelyn Avenue Bridge.



Photograph 5. Two adult steelhead trout observed in a pool 15 feet upstream of Central Avenue fish ladder in Stevens Creek on March 11, 2013. (S.Welch, 2013)

Passage Impediment Evaluation Evelyn Bridge

Due to the observations of spawning steelhead in the lower portions of Stevens Creek, District biologists evaluated upstream adult steelhead passage through the middle reaches of Stevens Creek on March 16, 2013. Biologists noted a passage impediment due to sediment accretion under the Evelyn Street Bridge. The channel invert under the bridge was visibly higher than the upstream invert which redirected flow

through the upstream high flow box culvert leaving the natural stream channel under the bridge and the Evelyn fish ladder dry (Photograph 6).

Physical dimensions of the box culvert, size (length and width), slope, and water depth were collected to determine if fish could ascend through the high flow box culvert to upstream reaches on March 16, 2013. The physical dimensions of the box culvert were compared to published criteria for fish passage and a determination was made as to characterize the barrier. Additional calculations based on the physical dimensions of box culvert were evaluated to determine how many days fish could pass the culvert during the 2013 migratory season.

Subsequent to the completion of the out-migrant trapping, District staff collaborated with the City of Mountain View to gain access to their facility for creation of a low flow channel to facilitate fish passage under the bridge by keeping medium and low flows in the natural channel. A longitudinal profile and cross section data was collected prior to creation of the low flow channel and that work was repeated after construction was complete on October 3, 2013.



Photograph 6. High flow box culvert upstream of Evelyn Street Bridge and adjacent section of Stevens Creek evaluated for fish passage.

Temperature Monitoring

In 2013, Stevens Creek stream temperatures were monitored at 11 locations with one above Stevens Creek Reservoir and 10 below the Stevens Creek Dam using Onset Water Temp Pro V2

sensors: precision = .01C, accuracy = +/- 0.2C (Figure 4). Sensors were programmed with Hobo Ware software v.2.3-3.4 at one hour intervals.

Devices deployed were those that successfully passed accuracy tests, being within the manufacturer's specifications. The manufacturer recommended a single step, Zero degree C ice bath test for calibration confirmation which was conducted.

Deployments at stream measurement locations for water temperature monitoring were redundant (two water sensors). Sensors placed in water were deployed in water in housings resistant to high flow events. Another sensor was placed at the same location out of the water in shade to record air temperature for a total of three sensors at each site. Data outputs downloaded from the sensors were converted using the manufacturer's software to an electronic file format that was managed in a relational Oracle database and outputs converted to Microsoft Excel files.

Temperature recorders were deployed at 11 locations in the watershed, one above Stevens Creek Reservoir and 10 below the reservoir to the trap site location (Table 2).

Table 2. Station location, cross street and distance downstream from dam for location of temperature loggers deployed in 2013.

Station Location	Location Cross Street	Distance Downstream of Dam (miles)
10290-25	Upstream of Stevens Creek Reservoir inlet	N/A
10290-26	Outlet to Stevens Creek Reservoir	0.1
10290-16	Upstream of Deep Cliff Drive at Golf Course	1.1
10290-14	At McClennen Road	1.9
10290-34	Blackberry Farms Park at upstream end of golf course	2.5
10290-11	Downstream Stevens Creek Road	3.0
10290-10	Upstream interstate 280	3.9
10290-35	Upstream Permanente Diversion	6.2
10290-27	Downstream Permanente Diversion	6.4
10290-1	At El Camino Real	7.7
10290-24	At Moffett Blvd trap site	10.0

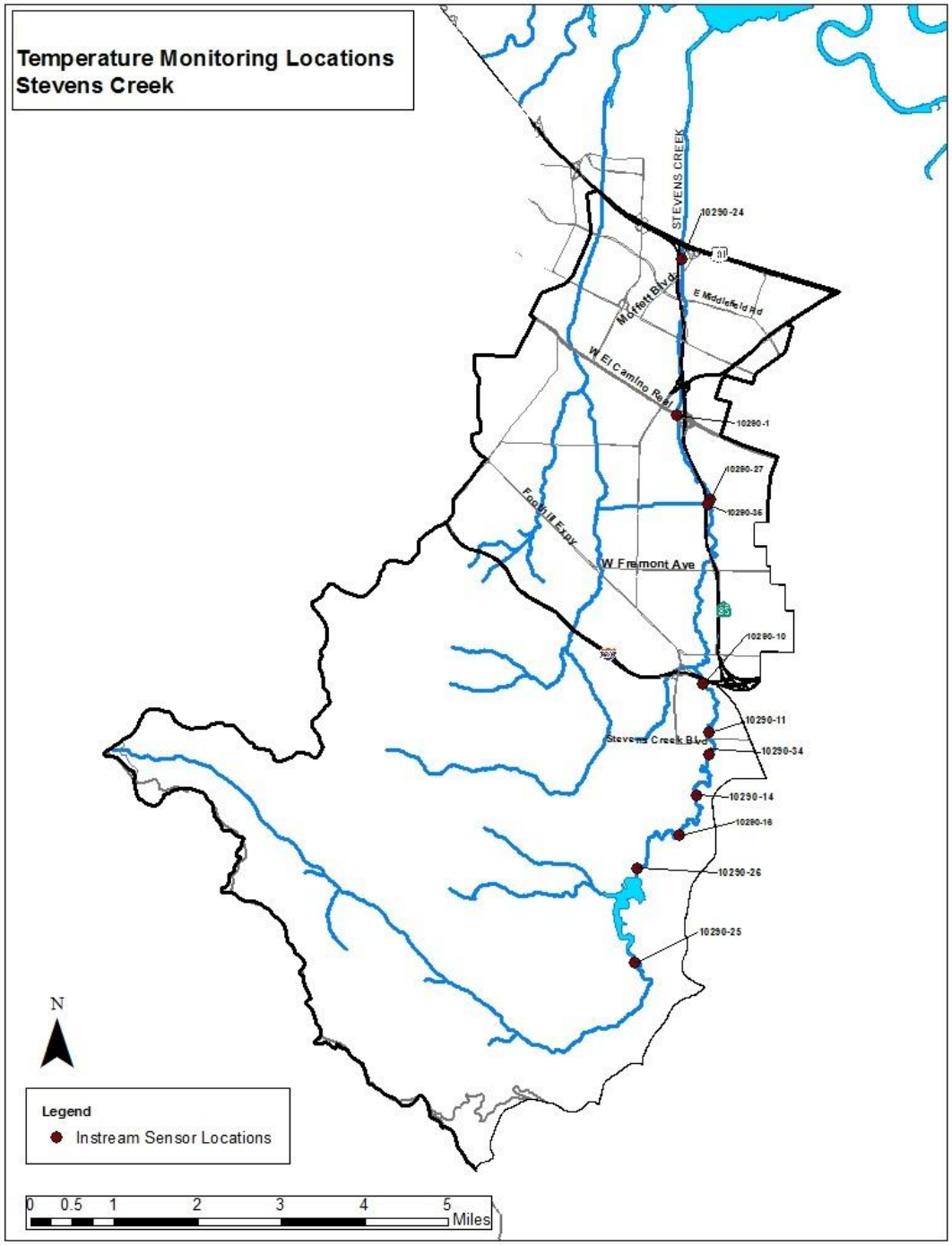


Figure 4. Locations of temperature logger deployment in Stevens Creek watershed, 2013.

Results

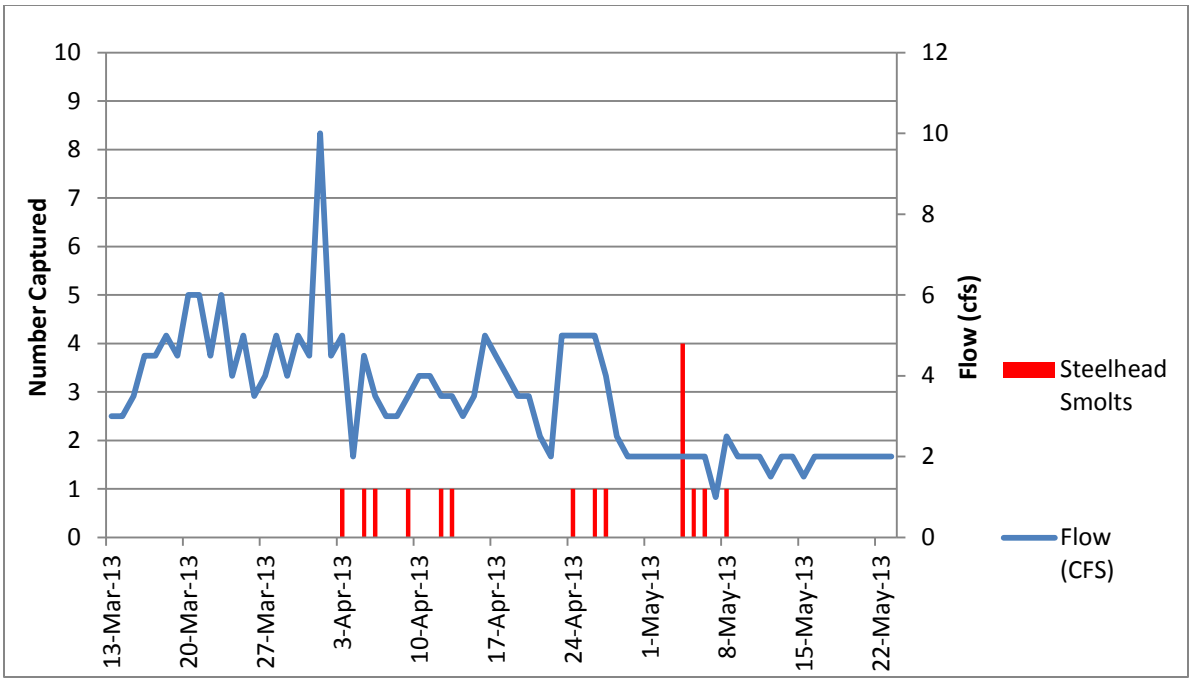
Out-migrant Trapping

The out-migrant weir trap downstream of Moffett Boulevard was operated for 72 consecutive days starting on March 12, 2013. Due to the receding instream flows and lack of connectivity to upstream portions of Stevens Creek and lack of smolt captures, the trap was discontinued May 23, 2013. The middle reaches of the stream, from Fremont Avenue to El Camino, began to dry back in late April and by May 5 standing water was found in some remnant pools in the middle reaches of stream with minimal flow ,>0.5 cfs , down to the fish trap at Moffett Boulevard .

Sixteen steelhead smolts were captured during the 2013 out-migrant season with the first captured on April 3 and the last capture on May 8th,, 2013 (Photograph 7). Smolts captured ranged in size from 120-215 mm fork length. All the smolts were individual captures with the exception of four smolts which were recaptures from an upstream mark/recapture exercise on May 4, 2013 (Graph 8). These smolts were relocated out of the Central Avenue Fish ladder on May 3, 2013 and released 1500 feet upstream of the trap site. Scales were taken off the four fish which served as a marking for identification upon recapture. Scales from the fish were given to CDFW then passed San Jose State University for age analysis as the fish relocation was conducted under a CDFW 4(d) permit.. No adult steelhead were captured in the trap for the 2013 season even though 7-10 adults were observed upstream of the trap site in and around theCentral Avenue fish ladder (Figure 1).

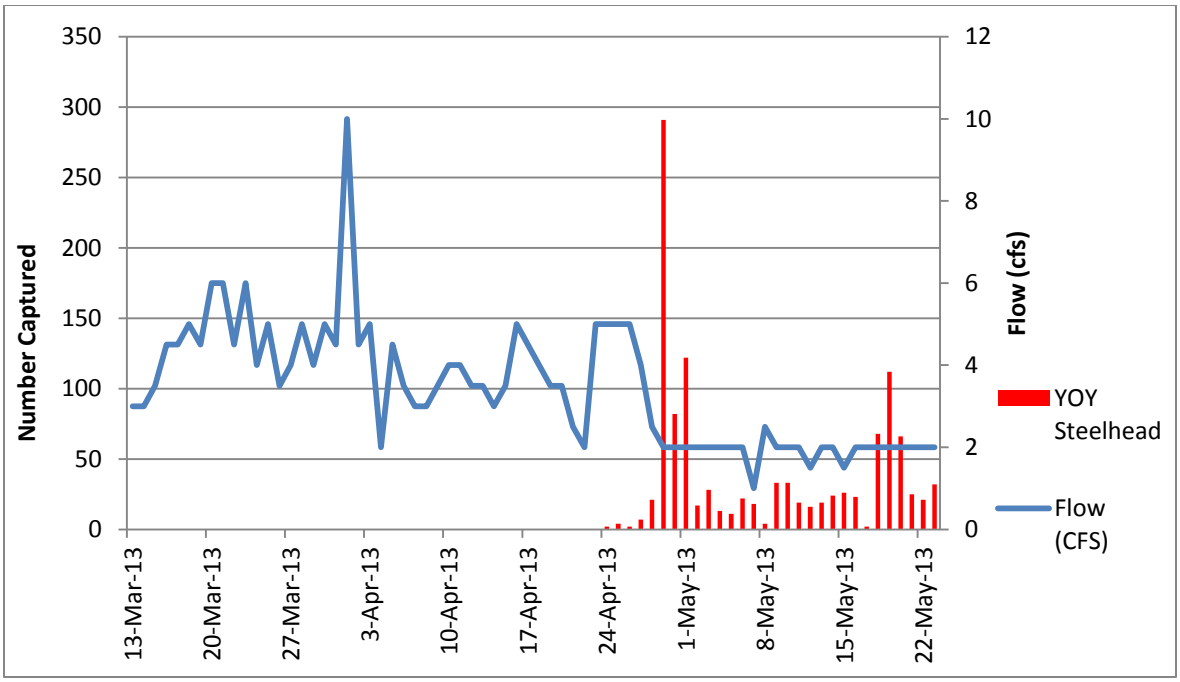


Photograph 7. Steelhead smolt captured in the out-migrant trap



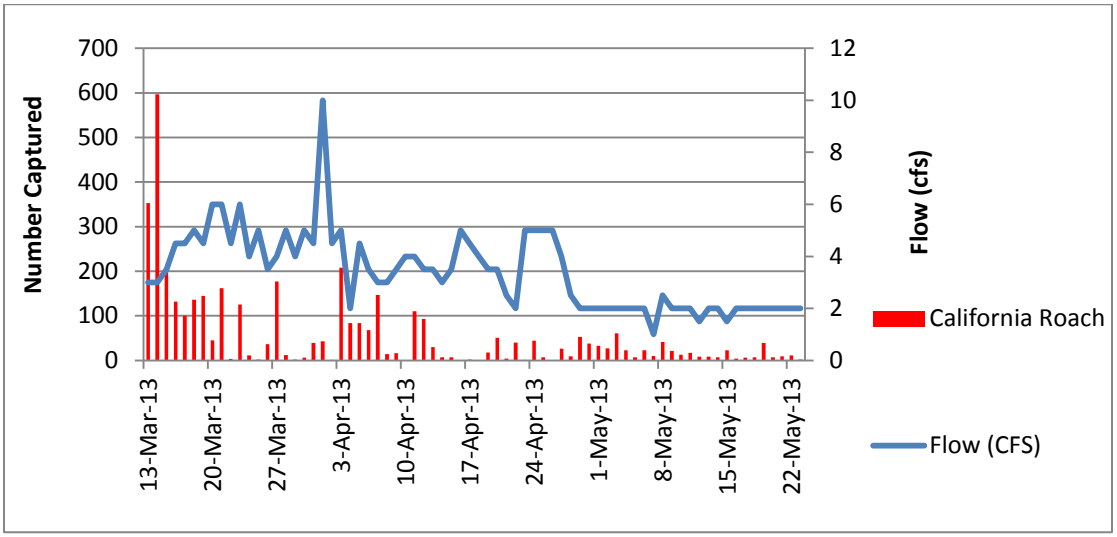
Graph 8. Steelhead smolt captures and corresponding flow for Stevens Creek out-migrant trapping for water year 2013.

Captured young of the year (YOY), 1163 in total, ranging in size from 19 mm-75 mm fork length were captured during the 2013 out-migrant trapping season with the first capture occurring on April 24 followed by abundant daily captures until the trap was removed on May 23, 2013 (Graph 9).

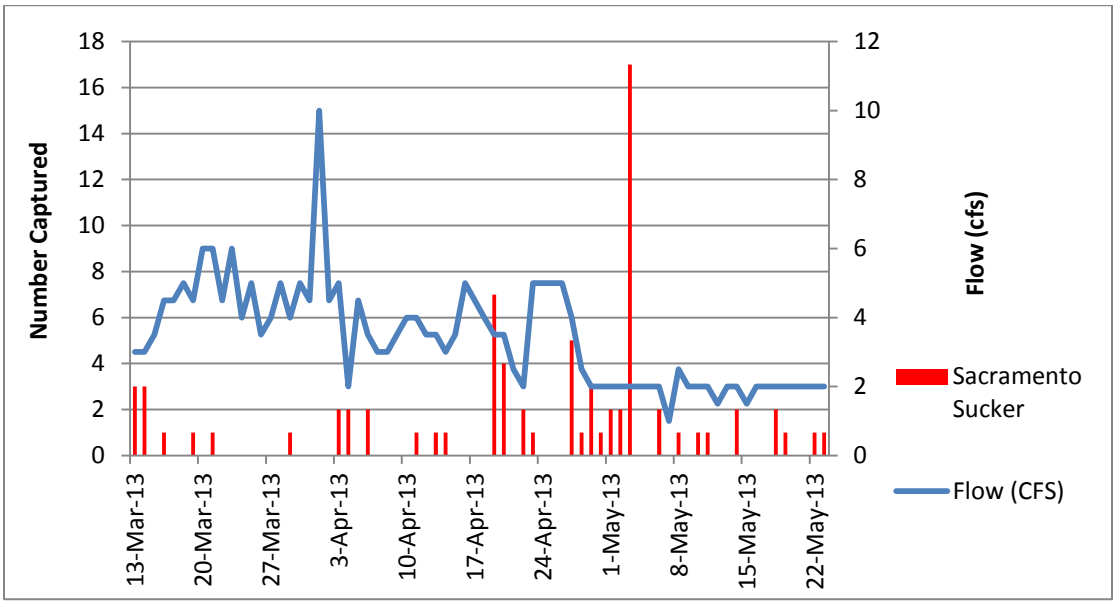


Graph 9. The result of captures for young of year steelhead and corresponding flow for Stevens Creek out-migrant trapping for water year 2013.

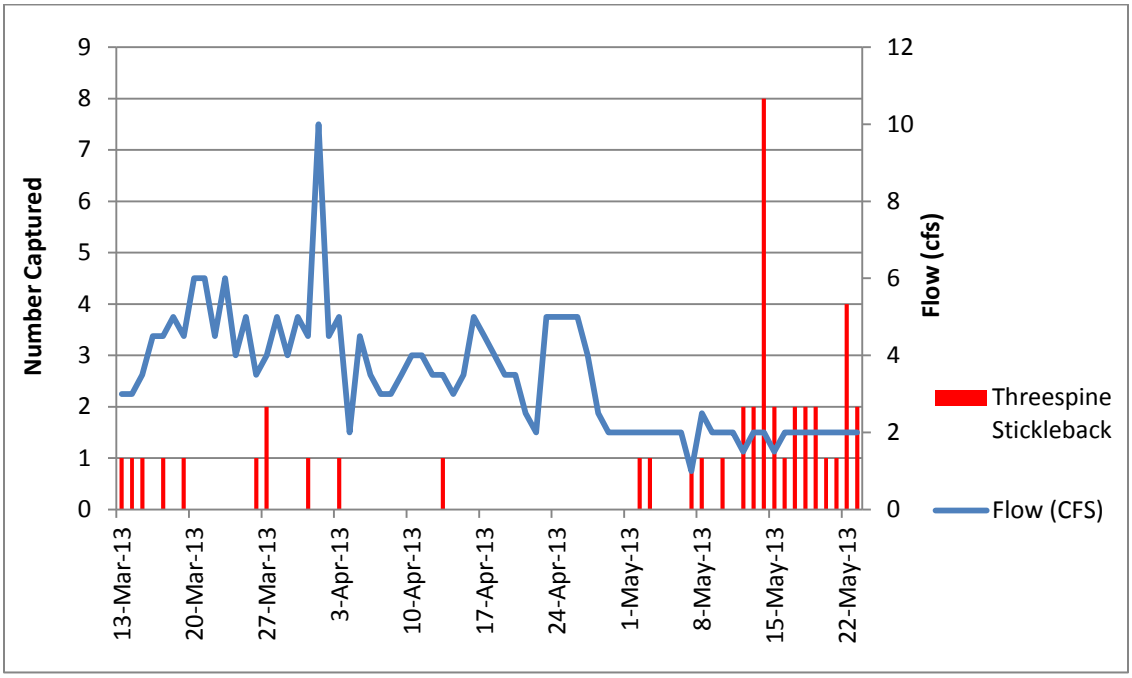
Only California native fin fish were captured in the trap boxes during the 2013 trapping season. All fish were identified to species, counted and released downstream to avoid recapture in the trap. OIn addition to steelhead, 3,893 California roach (*Lavinia symmetricus*) (Graph 10); 76 Sacramento sucker (*Catostomus occidentalis*) (Graph 11); and 45 threespine stickleback (*Gasterosteus aculeatus*) (Graph 12) were also captured.



Graph 10. Distribution of captures for trapping season 2013 of California roach with corresponding flow.



Graph 11. Distribution of captures for trapping season 2013 of Sacramento sucker with corresponding flow.



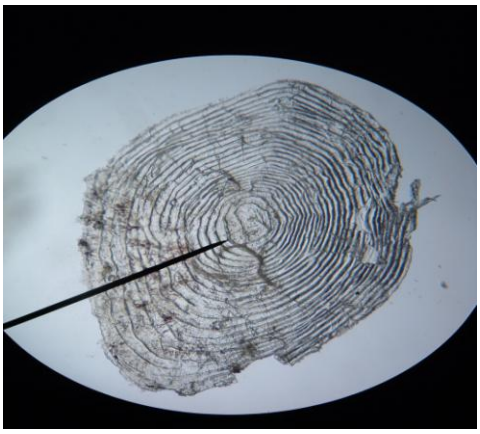
Graph 12. Distribution of captures for trapping season 2013 of threespine stickleback with corresponding flow.

Dryback Occurrence

For water year 2013, Stevens Creek flowed to the San Francisco Bay for 129 days. Flow became contiguous with the bay on December 22, 2012 and flowed continuously until April 29, 2013. The stream then dried just downstream of the Permanente Diversion canal and gradually receded further upstream to Fremont Avenue in July and further still to Homestead Road by September. Accreted flow from groundwater keeps the downstream reaches wet from Moffett Boulevard to San Francisco Bay to the end of the water year, September 30, 2013.

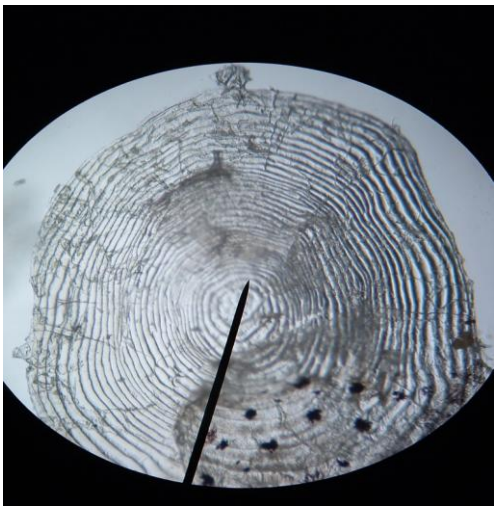
Scale Analysis

The scale analysis results were comprised a total of five fish, three 1+ fish ranging in size from 180-200 mm fork length and two 2+ 175 and 215 mm fork length respectively.

8.  9. 

Photograph 8. Depicts a steelhead smolt scale from a fish captured April 6, 2013. The size of the fish was measured at 200 mm fork length and the fish was aged at 1+. The pointer in the photograph depicts the "cutting over".

Photograph 9. Depicts a steelhead smolt scale from a fish captured in the trap April 13, 2013. The size of the fish was measured at 175 mm fork length and the fish was aged at 2+.

10.  11. 

Photograph 10. Depicts a steelhead smolt scale from a fish captured April 24, 2013. The size of the fish was measured at 180 mm fork length and aged as a 1+ fish. The pointer in the photograph depicts the "cutting over".

Photograph 11. Depicts a steelhead smolt scale from a fish captured in the trap May 6, 2013. The size of the fish was measured at 215 mm fork length and and aged as a 2+ fish. The pointer in the photograph depicts the "cutting over".

12. 

Photograph 12. Depicts a steelhead smolt scale from a fish captured in the trap May 8, 2013. The size of the fish was measured at 185 mm fork length and was aged as a 1+ fish. The pointer in the photograph depicts the "cutting over".

Spawning Surveys

The results of the two spawning surveys, conducted March 16 and 19, 2013, confirmed six steelhead redds and four possible redds in the mainstem of Stevens Creek from Moffett Boulevard to the Evelyn Street Bridge. Redd sites observed in 2013 in Stevens Creek at Central Avenue were less than 2 meters squared. A GPS point was collected of each of the sites and they were mapped (Figure 4).

As previously noted, on March 11, 2013 prior to the out-migrant trap installation, two adult steelhead were observed upstream of the Central Avenue fishway. Daily ocular surveys at this location revealed the presence of seven adult steelhead at Central Avenue on March 14, 2013. On this date, 2 pairs of steelhead were observed constructing a redd (Photograph 13). Adult fish were observed until March 27 at this location.

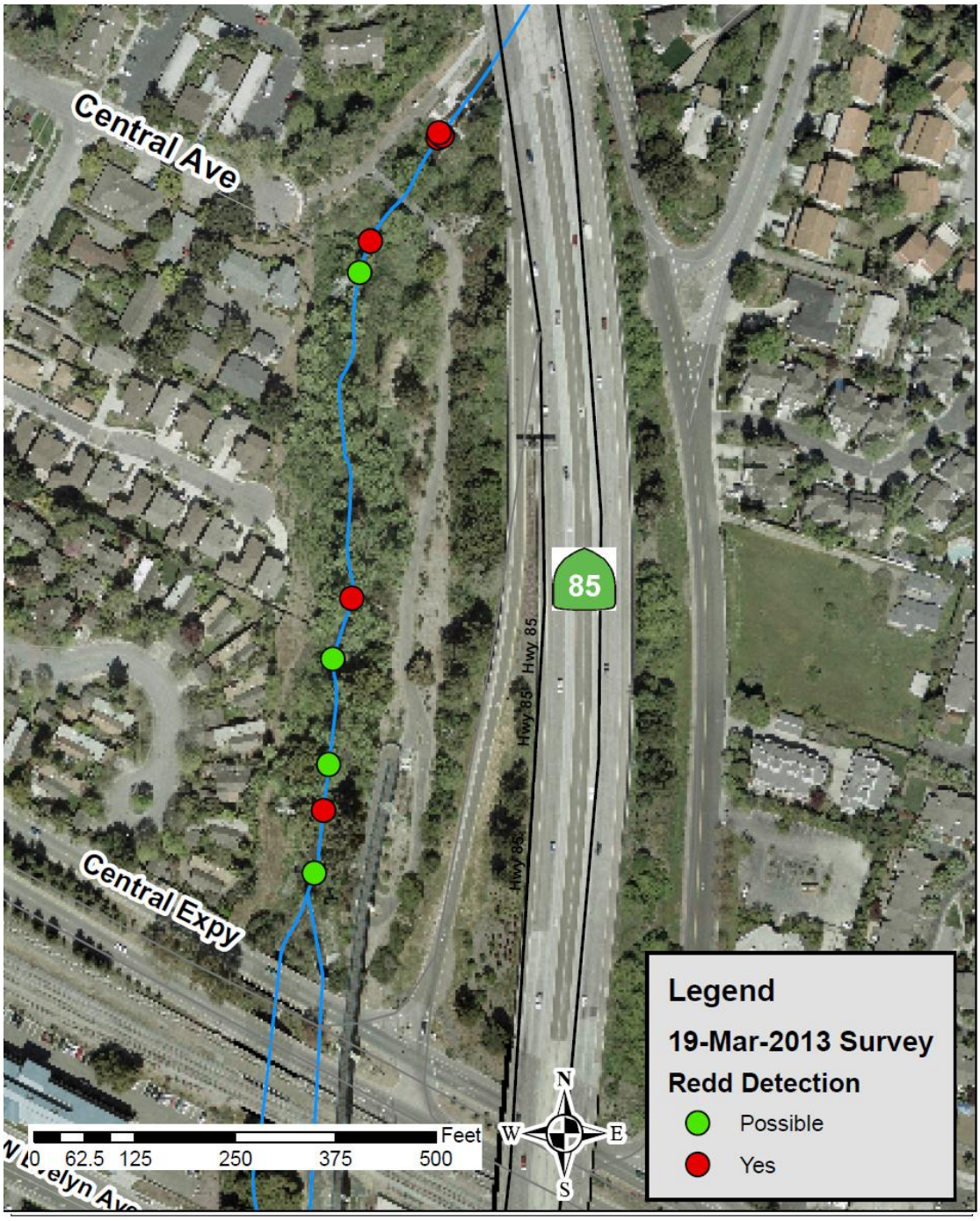


Figure 4. Results of redd surveys for steelhead conducted March 16 and 19, 2013 on Stevens Creek.



Photograph 13. Two adult steelhead constructing a redd upstream of the Central Avenue Fish Ladder, March 14, 2013.

Evelyn Avenue Bridge Passage Impediment

District biologists measured the culvert dimensions at the Evelyn Avenue Bridge box culvert and compared these dimensions against those published for fish passage for rainbow trout. The Evelyn box culvert dimensions measured were 469 ft. long, 14 ft. wide, 8 ft. tall, with a 7 ft. drop over the length of the culvert, resulting in a 1.5% gradient. The main channel width underneath the bridge was 36 ft. The measured depth of water in the culvert on 16 Mar 2013 was 1/10 of a ft., which was consistent throughout the entire length of the culvert.

Passage Criteria for Adult Steelhead Passage

To evaluate fish passage at the box culvert at Evelyn Avenue Bridge, specifications for passage of steelhead were evaluated using criteria from the CDFW Passage Evaluation at Fish Crossings (CDFW, 2003) and compared to existing conditions at the box culvert. To find the (Q) or flow which would equal a depth to support fish passage for adult fish, Manning's equation was set to equal the normal depth (0.8 feet) and the physical dimensions of the culvert were used to estimate the number of days in the 2013 migration season that fish could ascend the culvert.

Assuming subcritical flow: Flow (Q) which will equal a Normal Depth (y) =0.8 feet minimum depth for adult passage

Based on the following channel characteristics:

Width (b) = 14 ft, Slope (s) = 0.015, Manning's roughness (n) = 0.018

$(\frac{1.49}{n})(R^{.67})(s^{.5}) = \frac{Q}{A}$

A = area ($b*y_{nd}$) or ($14ft*y_{nd}$)

R = hydraulic radius or (A/P) = $\frac{(14y)}{(14+2y)}$

By trial and error: The following Q's were assumed:

Q=2 cfs y=0.10 feet (observed), .08 (calculated)

Q=50 cfs y=0.55 feet (calculated)

Q=80 cfs y=0.74 feet (calculated)

Q=90 cfs y=0.8 feet (calculated)

Q=100 cfs y=0.85 feet (calculated)

Table 1. Biological Criteria for swim speeds for adult and juvenile rainbow trout (CDFG, 2003).

	Biological Criteria For Adult Rainbow Trout	Biological Criteria For Juvenile Rainbow Trout
Fish Length	50 cm	20 cm
Minimum water depth	0.8 ft	0.5 ft
Prolonged Swim Speed	6 ft/s	4 ft/s
Prolonged time to exhaustion	30 min.	30 min
Burst swim speed	10 ft/s	5 ft/s
Burst time to exhaustion	5 s	5 s

The minimum water depth for low fish passage flows in the non-embedded culvert should be 0.8 ft for adults and 0.5 ft for juvenile passage (Table 1). Water depth within the box culvert at Evelyn Bridge was too shallow (i.e. 0.10 ft) for the 469 foot culvert length for both adult and juvenile fish to pass. Since the natural channel was dry adjacent to the box culvert, passage to upstream habitats was not available for most of the 2013 water year. Average daily flow at gauge station 35 for March 16, 2013 when flows in the box culvert were assessed was measured at 2.32 cfs. Based on calculated values, the flow in the box culvert would have to be 90 cfs to have the minimum depth available for adult steelhead to ascend (0.8 ft) the culvert. For the 2013 migratory season to take a conservative estimate, from December 1-March 31, 2013 flows reached 90 cfs or greater at the box culvert on 2 days. Both of those events occurred in December 2012.

With a calculated value of 90 cfs to obtain a 0.8 foot depth in the box culvert the question remained if the velocity in the culvert at this flow would further impede the passage of adult fish for the length of the culvert at 469 feet. The NMFS recommends that the average velocity in the culvert not exceed 1 foot per second for any length of culvert for juveniles and for culverts over >300 feet in length velocity does not exceed 2 fps for adult salmonids (NMFS, 2001). The velocity in the culvert was evaluated by calculating the velocity at normal depth.

V at (nd) =Q/A

90 cfs/ (14ft*0.8 ft) = 8.03 ft/sec=V_{nd}

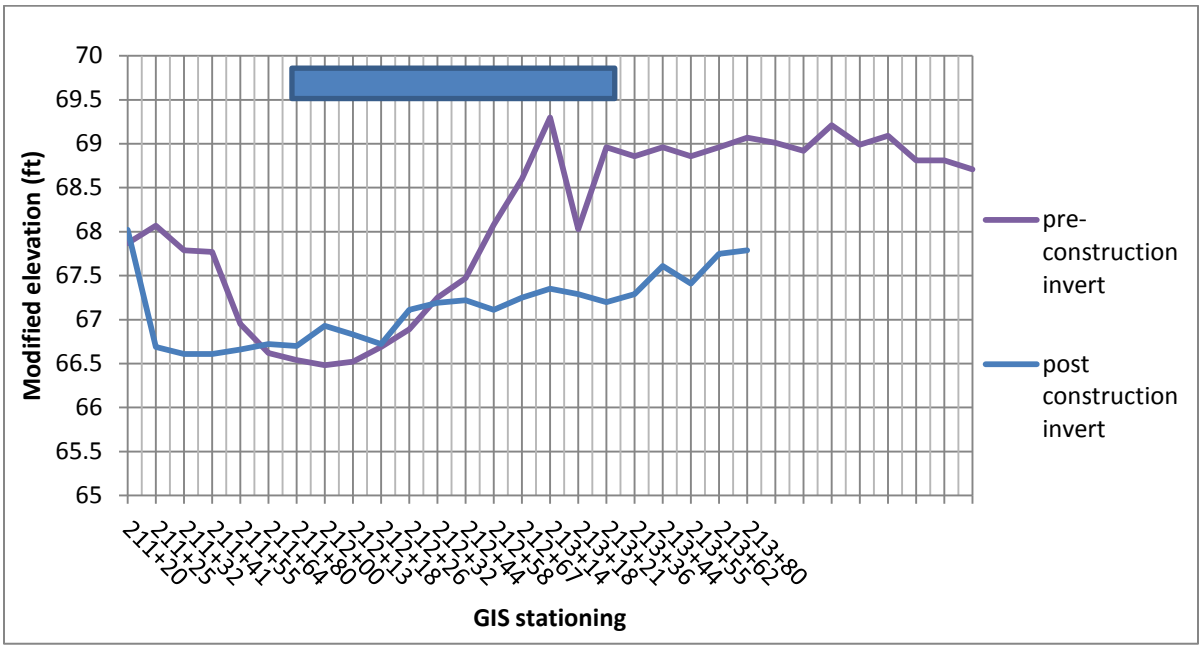
Based on the calculated information, the box culvert at the Evelyn Avenue Bridge presents both a depth and velocity impediment for the upstream passage of adult steelhead. Given flow conditions for the 2013 migration season it was concluded that adult fish could not migrate to the upstream portions of the stream to spawn. Visual observations of fish spawning in the lower portions of the watershed, downstream of this impediment, confirm this assertion.

It is unclear at this time what percentage of flow was directed to the box culvert versus what went down the natural channel in the 2013 migratory season. The fish passage evaluation revealed that all flow was directed to the box culvert at 90 cfs but presumably some flow traversed the natural channel once the flow was higher than the accreted sediment underneath the bridge.

District watershed staff has since created a low flow channel under the Evelyn Avenue Bridge to ameliorate poor passage conditions at the Evelyn Avenue Bridge for fish (Photograph B). A longitudinal profile was collected pre and post construction to establish a baseline for passage conditions and to determine how much sediment had accreted (Graph 13). Approximately 3 feet of accreted sediment was relocated to create a floodplain to direct the flows to the low flow channel. Passage conditions at the bridge will be monitored for the 2014 migratory season



Photograph 14. Looking downstream at the Evelyn Avenue Bridge low flow channel were construction was completed October 3, 2013.



Graph 13. Pre and post construction longitudinal profile downstream of the Evelyn Avenue Bridge. The blue box indicates location of the bridge.

Discussion

Smolt Captures and Flow Conditions

Capture numbers of smolts in 2013 were low (16) likely to dry instream conditions, magnitude, frequency, and timing of storm events, and lack of connectivity to upstream habitats during the outmigration season. The stream remained wet to SF bay from December 22 to April 29th but flows were notably lower than average and flow related barriers are believed to have contributed to limited smolt migration in 2013 (Stillwater Science, 2004) (Balance Hyrologics Inc., 2002). Flow was measured at gauge station 44 at 10.8 cfs from March 1-March 31st flows were reduced to below 10 cfs until April 29th when flows were further reduced to below 5 cfs. The middle reaches of Stevens Creek were discontinuous for the duration of the trapping period from April 29th to May 23, 2013. Flow at gauge station 35 dropped to less than a half of a cfs until the stream completely dried in June, 2013. Due to the low number of smolt captures a trap efficiency analysis was not conducted for this trapping season.

Previous work was conducted in Stevens Creek for the TCHCP effort, formally known as Fisheries and Aquatic Habitat Collaborative Effort (FAHCE) for flow related barriers for steelhead in 2000 (FAHCE, 2000). Potential flow related barriers were identified, which included naturally formed riffles, where the channel geometry at low flows could potential limit passage of adult and juvenile fish. The criteria used in the earlier work assumed a minimum depth requirement of 0.8 ft for both adult and juvenile fish passage (Thompson, 1972) over the identified critical areas. A generalized stage to discharge relationship was developed by a third-party Technical Advisory Team for FAHCE to obtain the minimum depth threshold and the results were a corresponding discharge of 16 cfs from reservoir releases. To account for the fact that the channel geometry at the identified critical passage areas where the stage/discharge relationship was developed did not represent the wider, shallower areas of Stevens Creek the number was doubled to 32 cfs for analysis purposes as a conservative estimate for fish passage.

Additional information associated with flow related barriers was collected by Balance Hydrologics in Stevens Creek in 2002 (Balance Hydraulics, 2002) for the FAHCE program. The same minimum depth requirement (0.8 ft) was used in this study to characterize six critical riffles which were believed to limit passage for both adult and juvenile fish. Hydraulic models were set up for each of the riffles to assess the passage discharge that would meet the minimum depth requirements and allow for ease of passage for fish. The results of that analysis indicated that 20 cfs would provide the adequate depth necessary for passage through the six flow related impediments.

Adult Migration

For adult up-migration in water year 2013, it was determined that the flow/structural related barrier at Evelyn Bridge and box culvert, 8.2 miles downstream of Stevens Creek reservoir, was a complete passage barrier for adult fish. This structure appeared to have limited smolt migration due to the shallow sheet flow in the box culvert. However, it seems equally plausible that other flow related structures and riffles which were previously identified upstream of Evelyn in the afore mentioned studies, also may have contributed to the low numbers of smolts since flows did not exceed 11 cfs from January-May 2013 in the upper and transition portions of Stevens Creek.

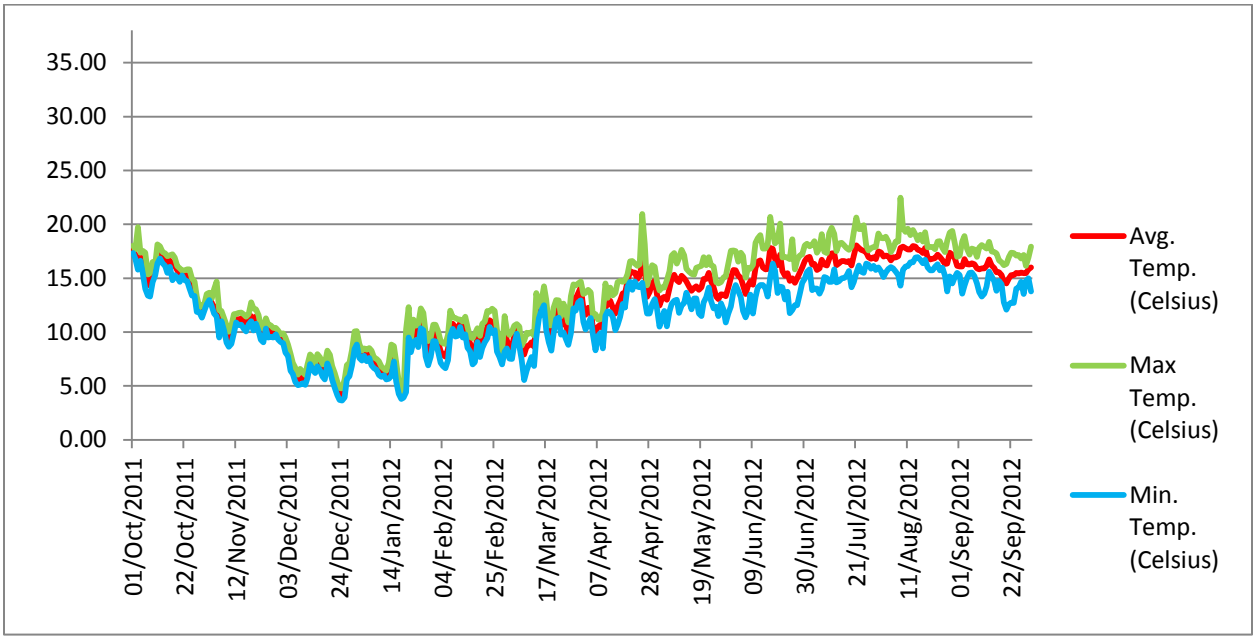
YOY and Spawning

The flow related barrier at Evelyn Avenue Bridge did lead to the observation of spawning adults in the lower reaches of Stevens Creek, 8.2-8.8miles downstream of Stevens Creek reservoir. Subsequently, this lead to a high capture of young-of- year (YOY) fish in the out-migrant trap for 2013. This evidence suggests that successful spawning and emergence did occur in the middle and lower reaches of stream since there was no connectivity to upstream habitats. Steelhead trout require 26 days at 12 ºC to reach 50% hatch (Meehan, 1991). Steelhead were observed laying redds March 14, 2013 where water temperatures recorded close to the site, at El Camino Real were between 11-13 ºC so 50% hatch was estimated around April 9, 2013. The first young of the year captured in the out-migrant trap occurred April 24th and subsequently abundant captures of YOY were found in the trap daily until the trap was removed on May 23, 2013.

The scale analysis revealed that the smolts captured during the 2013 trapping period were comprised of 1+ and 2+ individuals. While sample size was small, information for the two previous water years for which the 2013 captured smolts reared in freshwater were included in this report. As more information is obtained during future trapping efforts in Stevens Creek this information will be utilized to look for trends in watershed productivity for smolt production.

In a collaborative effort between the California Department of Fish and Wildlife and San Jose State University seven sites in Stevens Creek were electrofished on August 9 and 10, 2013. Subsequently, four sites were again sampled October 6 and 7, 2013. At the time this report was prepared; the CDFW had not yet completed their monitoring report for that data collection effort. CDFW did prepared a summary of data findings for inclusion in this report which will be cited as draft. Pertinent to the observations for this report, was the persistence of steelhead through the summer in middle and lower sections of Stevens Creek. Juvenile *O. mykiss*were present at Moffett Boulevard in August and common downstream of Highway 101, 9.8 river miles downstream of Stevens Creek reservoir, in both August and October. The total *O. mykiss* densities downstream of HWY 101 cited in the summary was 23.0 fish per 30.5 m in August and 14.7 fish per 30.5 m in October. A rain event occurred between the August and October sampling which moved fish and young of the year from upstream were present in October (CDFW, 2013).

Accreted ground water flow kept temperatures cooler in the section of Stevens Creek (middle and lower) from Central Avenue to Highway 101 which may have contributed to the persistence of *O. mykiss* in the summer for water year 2013. Summer time water temperatures for water year 2013 are not yet processed for the lower sections of the stream. However, 2012 summer water temperatures recorded at El Camino Real for Stevens Creek found that the average daily temperature stayed below 20 º C (Graph 14).



Graph 14. Average daily water temperatures, including maximum and minimum temperatures, for Stevens Creek collected at El Camino Real for partial water year 2012 from October 1, 2011 to September 22, 2012.

The second year of out-migrant trap monitoring will commence for Stevens Creek in spring 2014. The data will be synthesized with the first year effort and any other relevant fisheries data collected by other agencies. Flow related barriers will be evaluated in further detail to build on the previous data collection efforts undertaken by the TCHCP project. Water temperature and flow data will be again collected for year 2 monitoring efforts to assist with analysis after the third year of baseline monitoring is complete (Appendix B).

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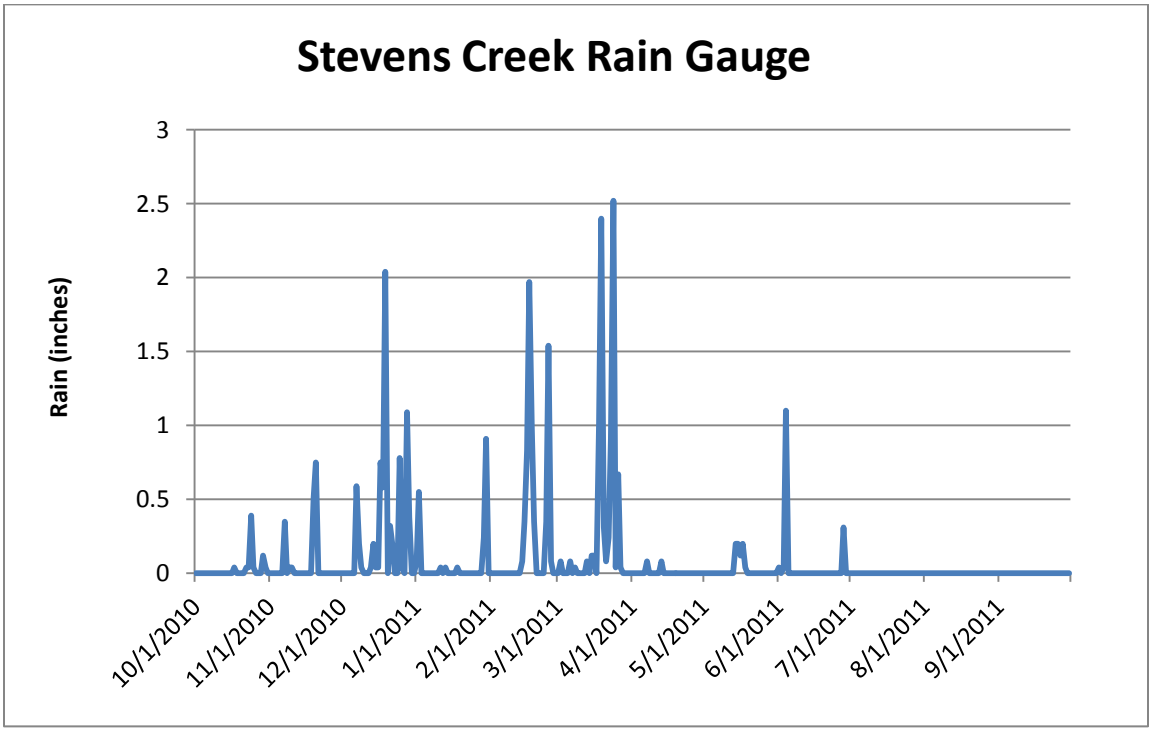
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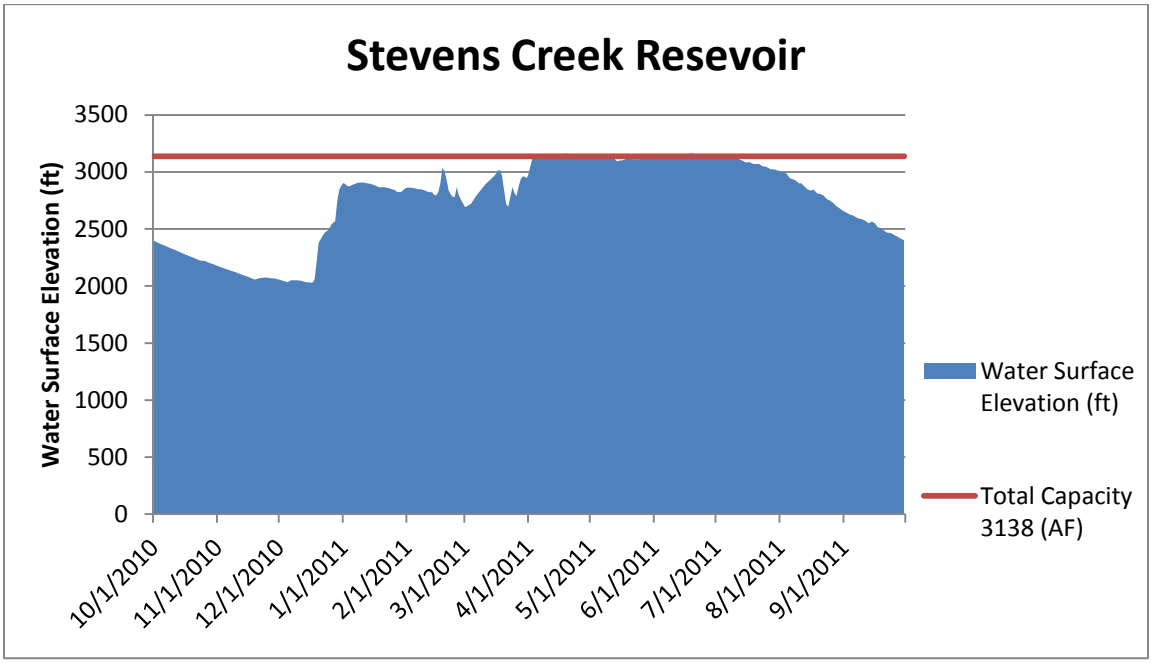
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APPENDIX A

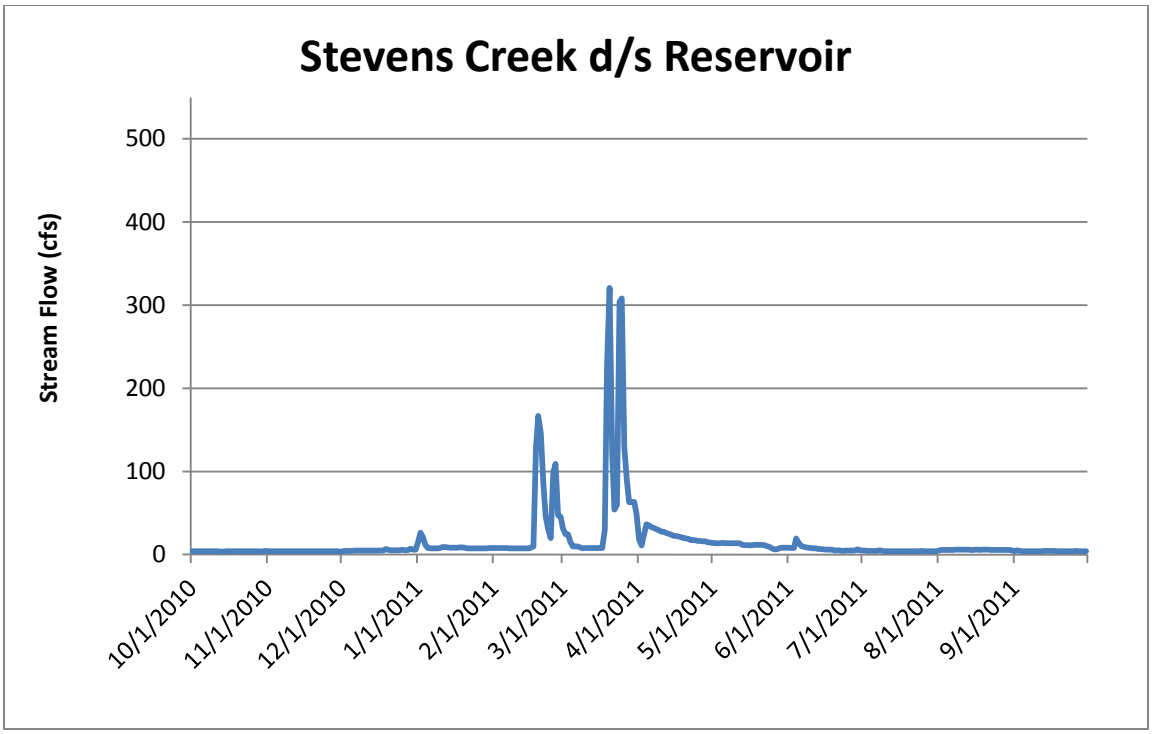
Hydrologic data is presented for the two water years prior to the installation of the smolt trap to account for the fact captured smolts were aged at 1+ and 2+. Rainfall data, reservoir storage data and hydrographs for the two District operated stream gauges are presented in this Appendix generated from finalized Wiski hydrologic database data managed by the district Hydrologic Data Measurement and Management Project. Further analysis will occur with this data once year three monitoring is complete.



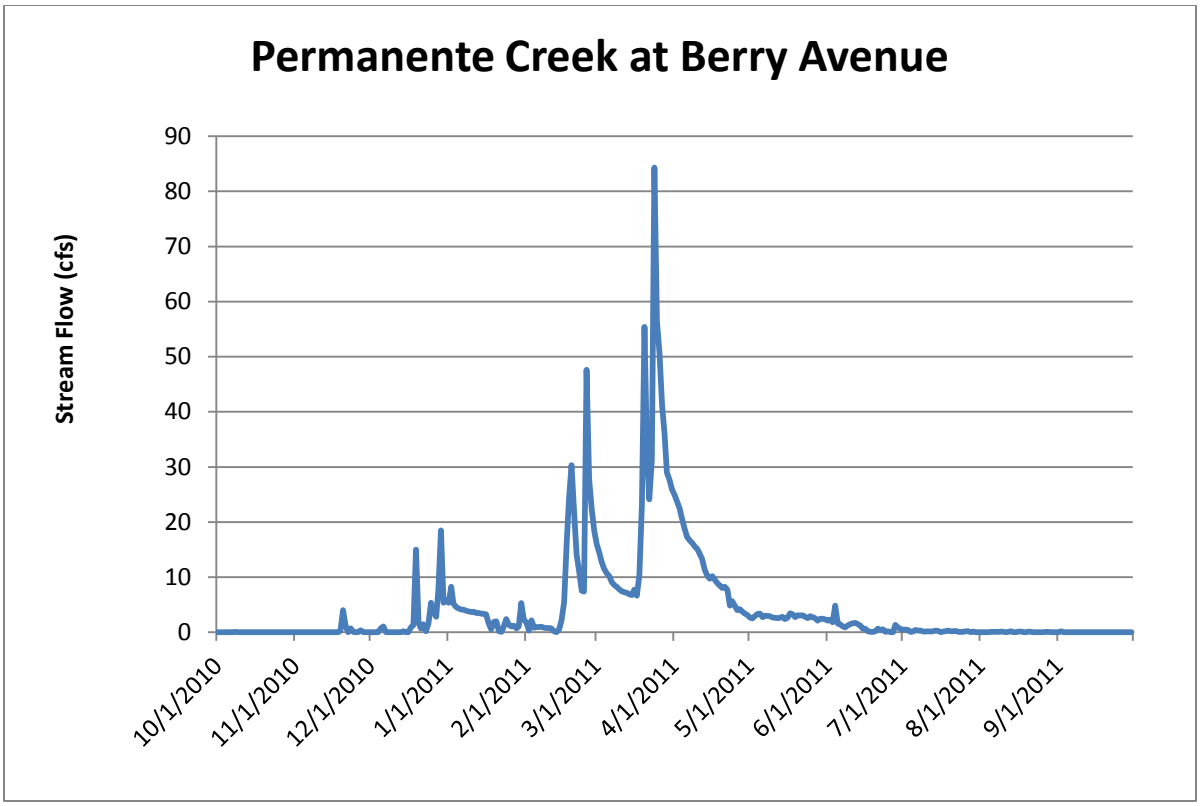
Graph 1a. Daily rainfall totals (inches) for water year 2011 (Oct. 1, 2010 to Sept. 30, 2011) Data was obtained from a District precipitation gauge 6100 (elevation 499 feet above sea level) located off Stevens Canyon Road. A total of 29.3 inches was recorded for water year2011.



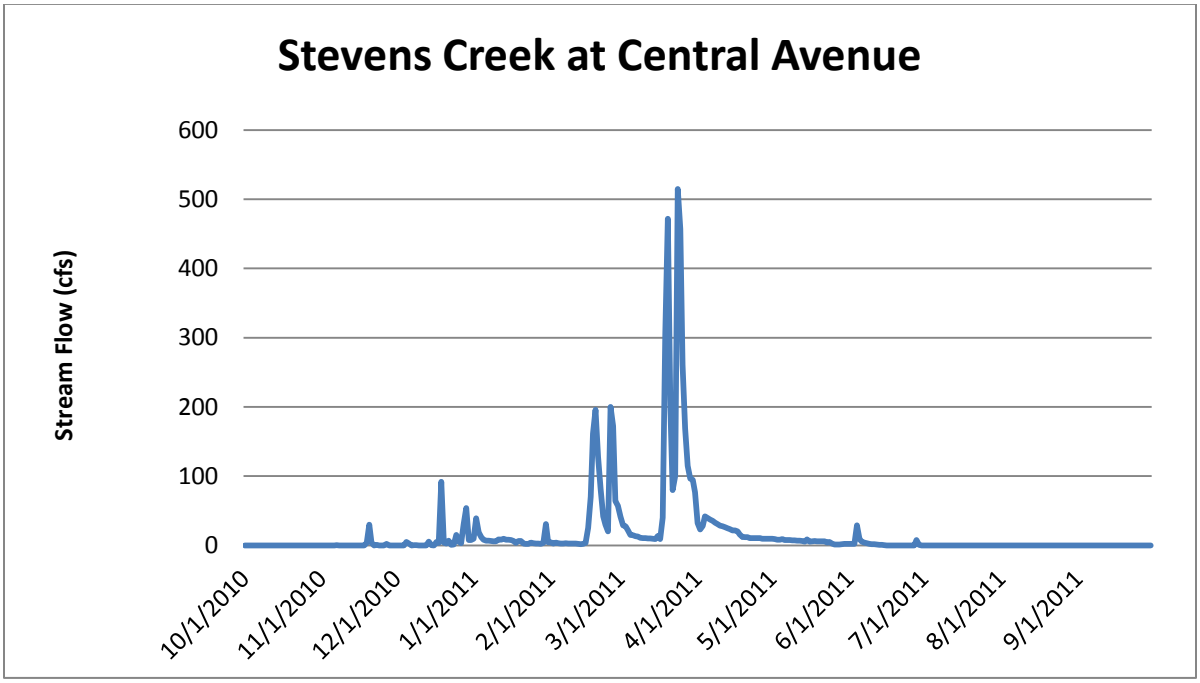
Graph 2a. Water surface Storage in acre-feet at Stevens Creek Reservoir for water year 2011.



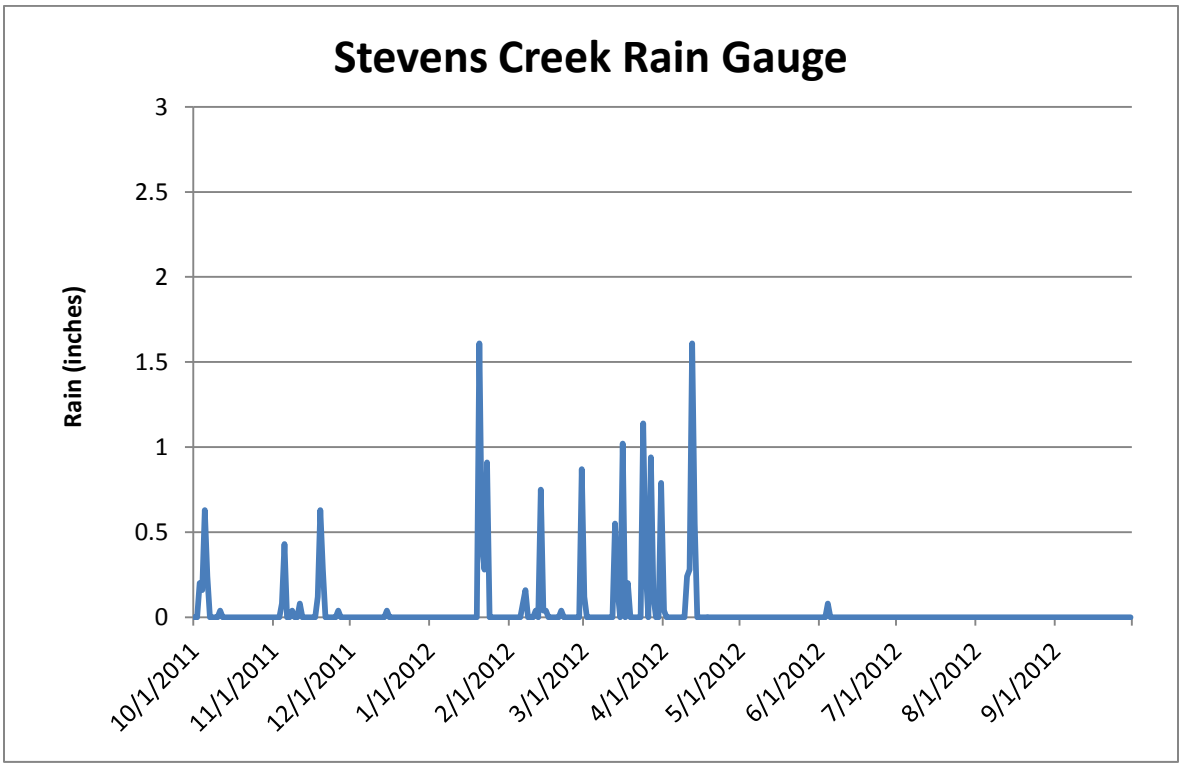
Graph 3a. Average daily stream flow (cfs) measured at District operated stream gauge number 44 located 0.6 miles downstream of Stevens Creek Reservoir for water year 2011.



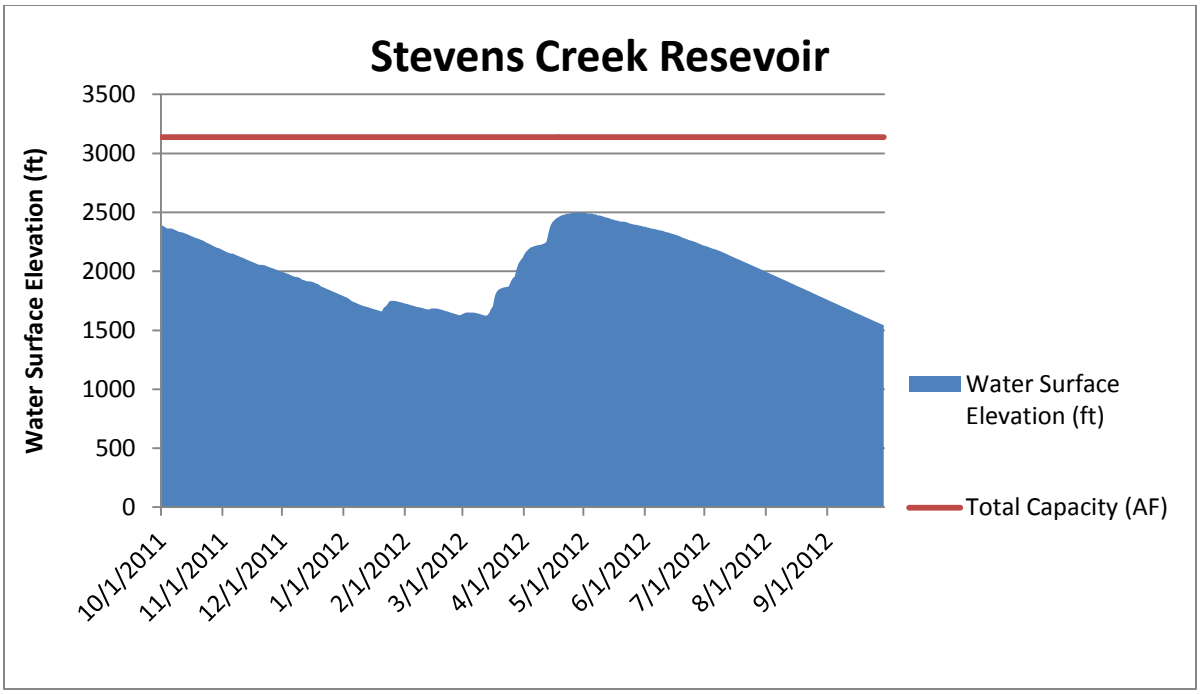
Graph 4a. Flow contributions to Stevens Creek from the upper portions of the adjacent Permanente watershed measured at District operated gauge, 32.1 located in Permanente Creek immediately upstream of diversion canal. Average daily flow (cfs) is graphed for water year 2011.



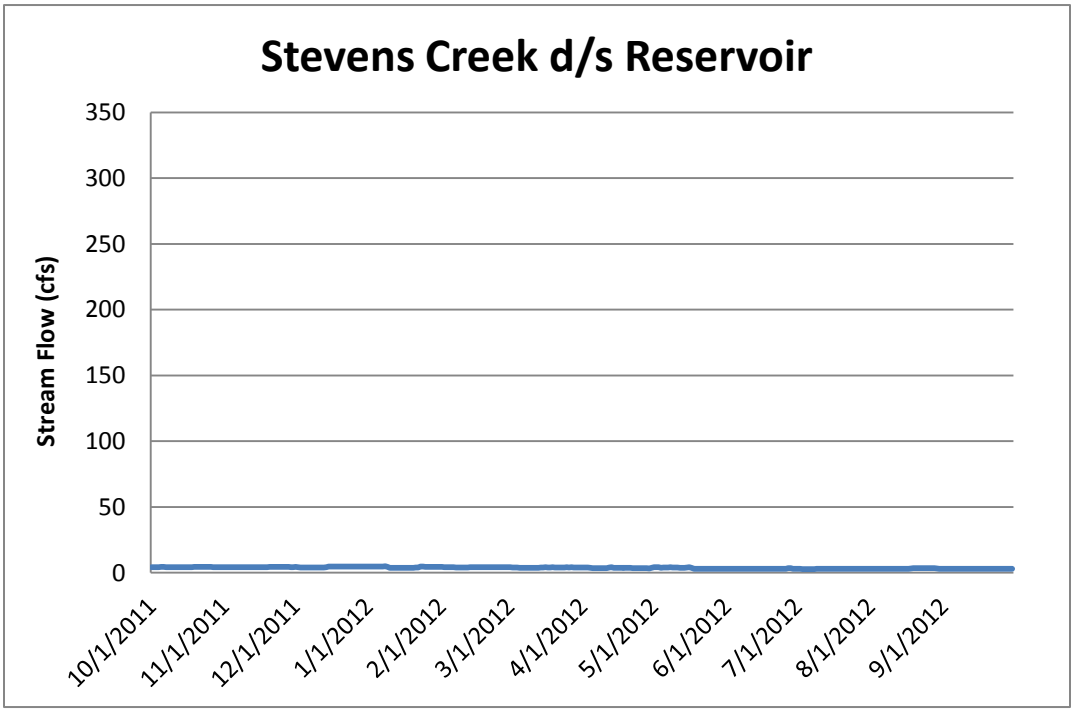
Graph 5a. Average daily stream flow measured at District operated stream gauge 35 located 8.8 miles downstream of Stevens Creek reservoir.



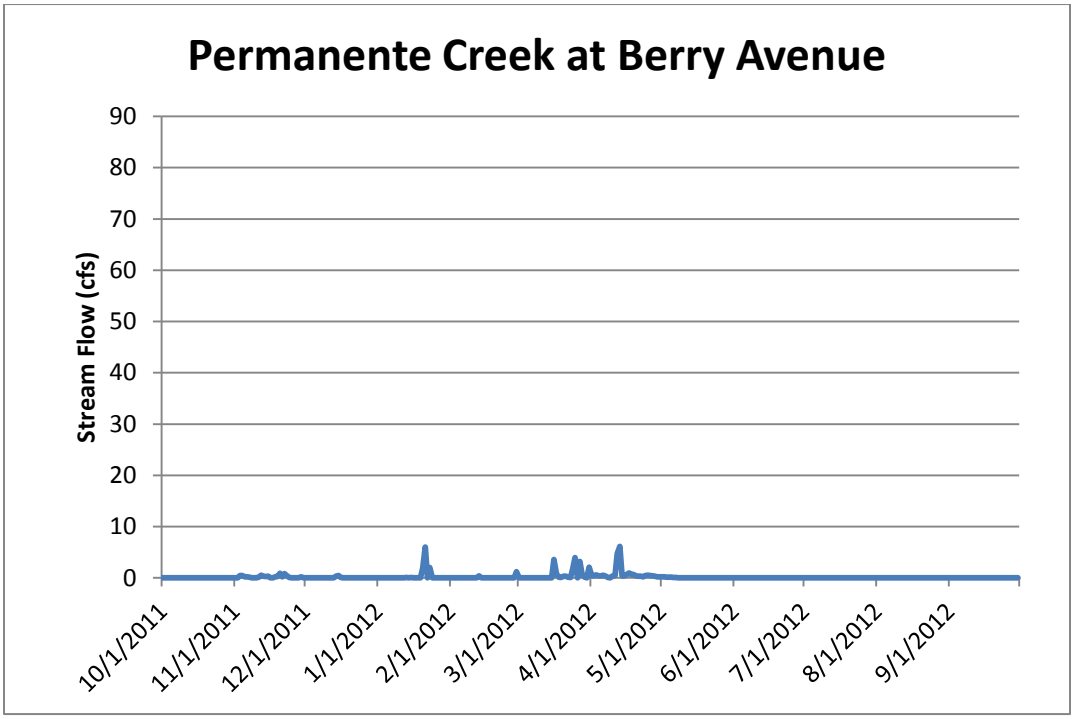
Graph 6a. Daily rainfall totals (inches) for water year 2012. Data was obtained from a District operated precipitation gauge 1510 (elevation 499 ft) located off Stevens Canyon Road. A total of 16.38 inches was recorded for water year 2012.



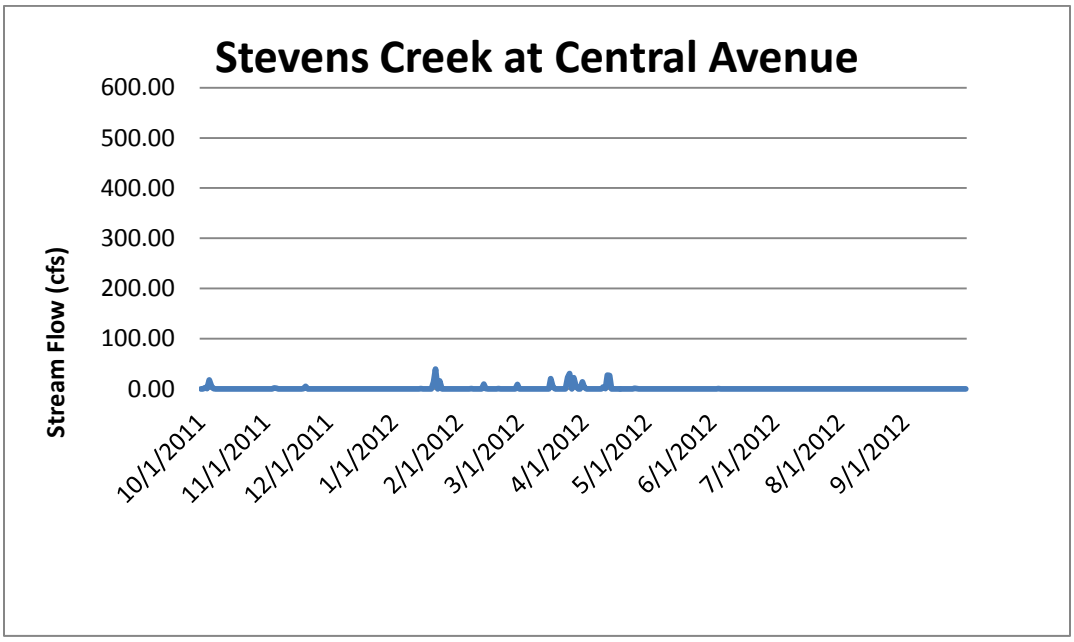
Graph 7a. Water surface elevation at Stevens Creek Reservoir (feet) for water year 2012.



Graph 8a. Average daily stream flow (cfs) measured at District operated stream gauge 44 located 0.6 miles downstream of Stevens Creek Reservoir for water year 2012.



Graph 9a. Flow contributions to Stevens Creek from the upper portions of the adjacent Permanente watershed measured at District operated gauge, 32.1 located in Permanente Creek immediately upstream of diversion canal. Average daily flow (cfs) is graphed for water year 2012.



Graph 10a. Average daily stream flow measured at District operated stream gauge 35 located 8.8 miles downstream of Stevens Creek reservoir.

APPENDIX B

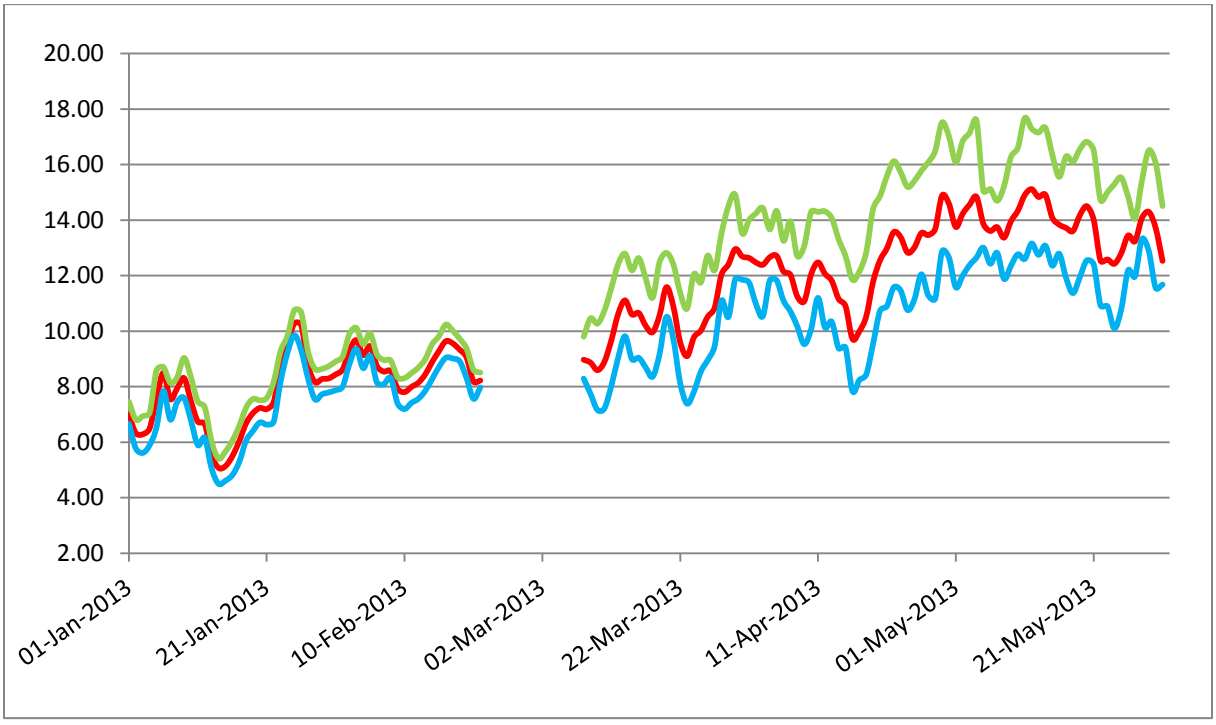
The water temperature data presented in this report represents a fraction of temperature data which was collected and continues to be collected for the TCHCP program. However, since analysis of temperature and flow data will occur after year three out-migrant trapping is complete, only a portion of the data is presented here. Continuous data sets of temperature will be compiled and reported for year 3 analysis and final report for Stevens Creek.

Temperature graphs are presented in this Appendix from the most upstream station, above the Stevens Creek Reservoir (10290-25) to the most downstream temperature location, the trap site downstream of Moffett Boulevard (10290-24).

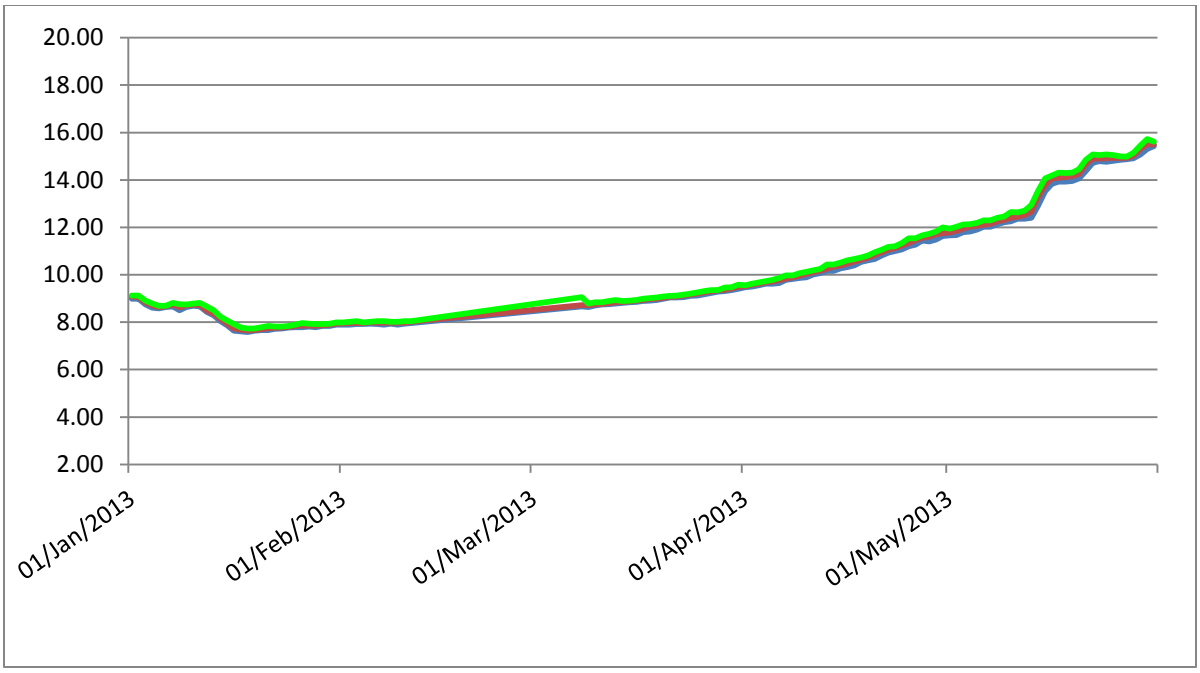
Table 2. Station location, cross street and distance downstream from dam for location of temperature loggers deployed in 2013.

Station Location	Location Cross Street	Distance Downstream of Dam (miles)
10290-25	Upstream of Stevens Creek Reservoir inlet	N/A
10290-26	Outlet to Stevens Creek Reservoir	0.1
10290-16	Upstream of Deep Cliff Drive at Golf Course	1.1

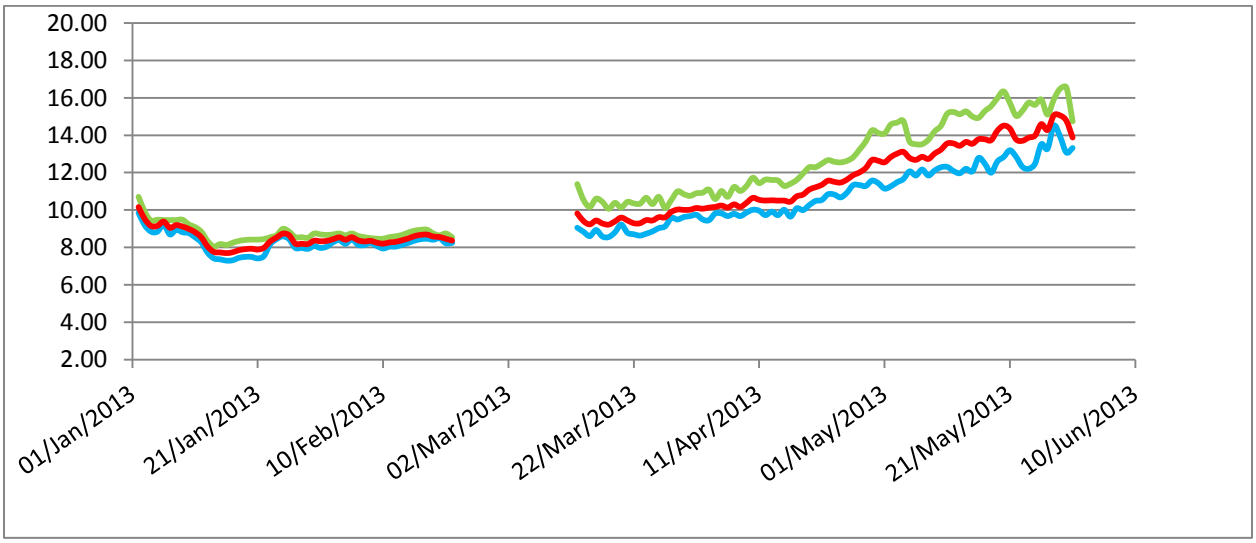
10290-14	At McClennen Road	1.9
10290-34	Blackberry Farms Park at upstream end of golf course	2.5
10290-11	Downstream Stevens Creek Road	3.0
10290-10	Upstream interstate 280	3.9
10290-35	Upstream Permanente Diversion	6.2
10290-27	Downstream Permanente Diversion	6.4
10290-1	At El Camino Real	7.7
10290-24	At Moffett Blvd trap site	10.0



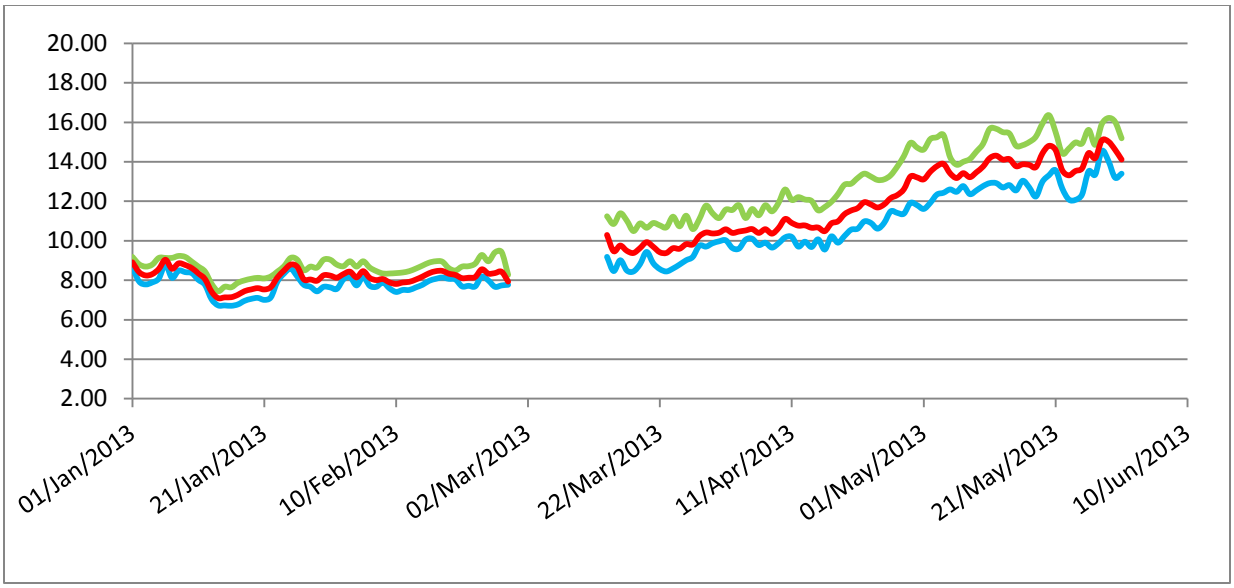
Graph 1b. Average daily water temperature (ºC) collected upstream of Stevens Creek Reservoir at the inlet (Temperature station # 10290-25) and is depicted on the graph in red from January 1, 2013 through March 31, 2013.Maximum daily temperature is depicted in green and minimum daily temperature in blue. The gap in data collection, February 21-March 8 2013 was due to servicing and refurbishing equipment.



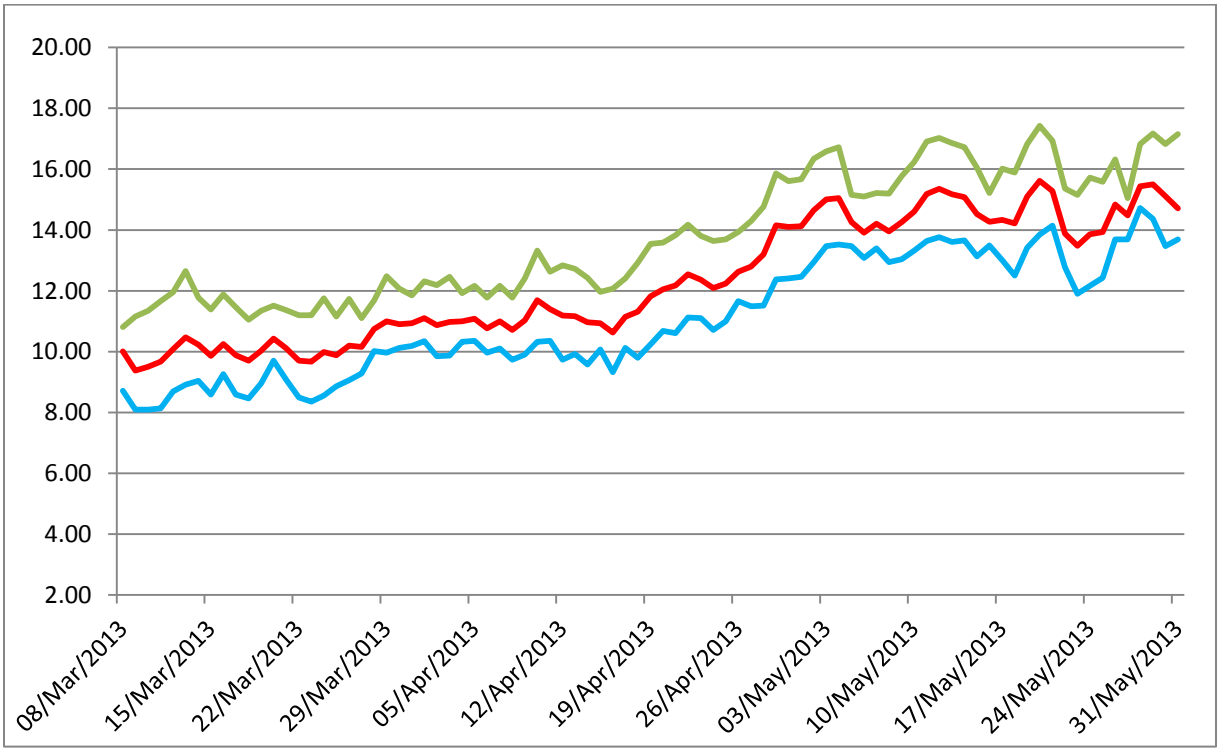
Graph 2b. Average daily water temperature (ºC) collected downstream of Stevens Creek Reservoir at the outlet (Temperature station # 10290-26) and is depicted on the graph in red from January 1, 2013 through March 31, 2013.Maximum daily temperature is depicted in green and minimum daily temperature in blue.



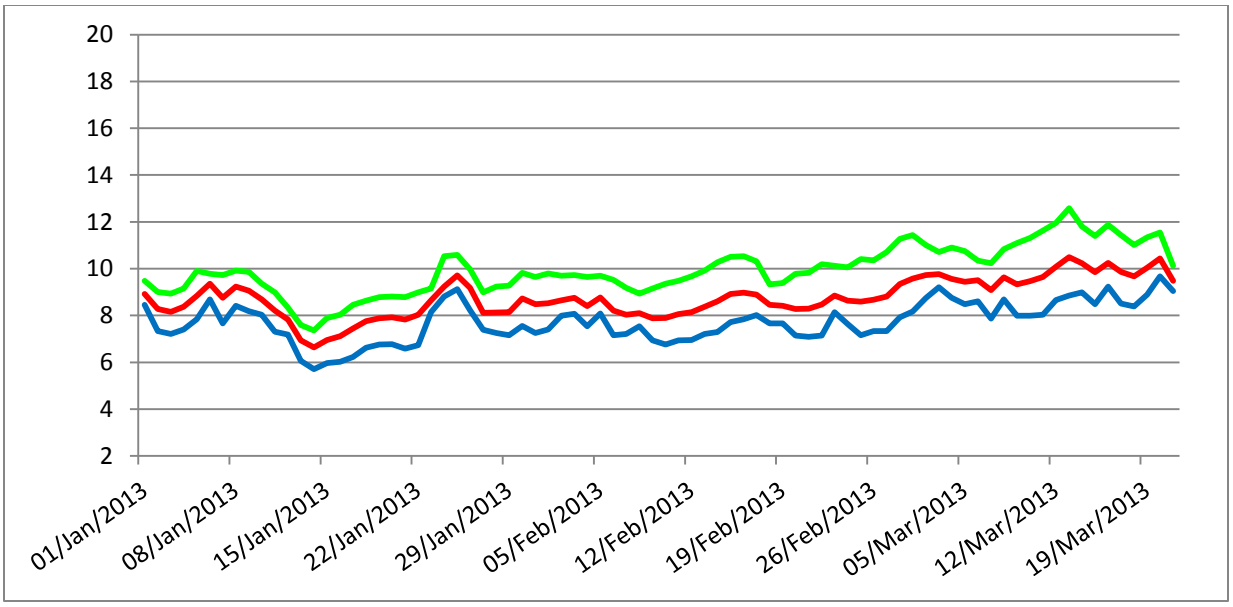
Graph 3b. Average daily water temperature (ºC) collected upstream of Deep Cliff Drive (Temperature station # 10290-16) and is depicted on the graph in red from January 1, 2013 through March 31, 2013.Maximum daily temperature is depicted in green and minimum daily temperature in blue. The gap in data collection, February 21-March 14 2013 was due to servicing and refurbishing equipment.



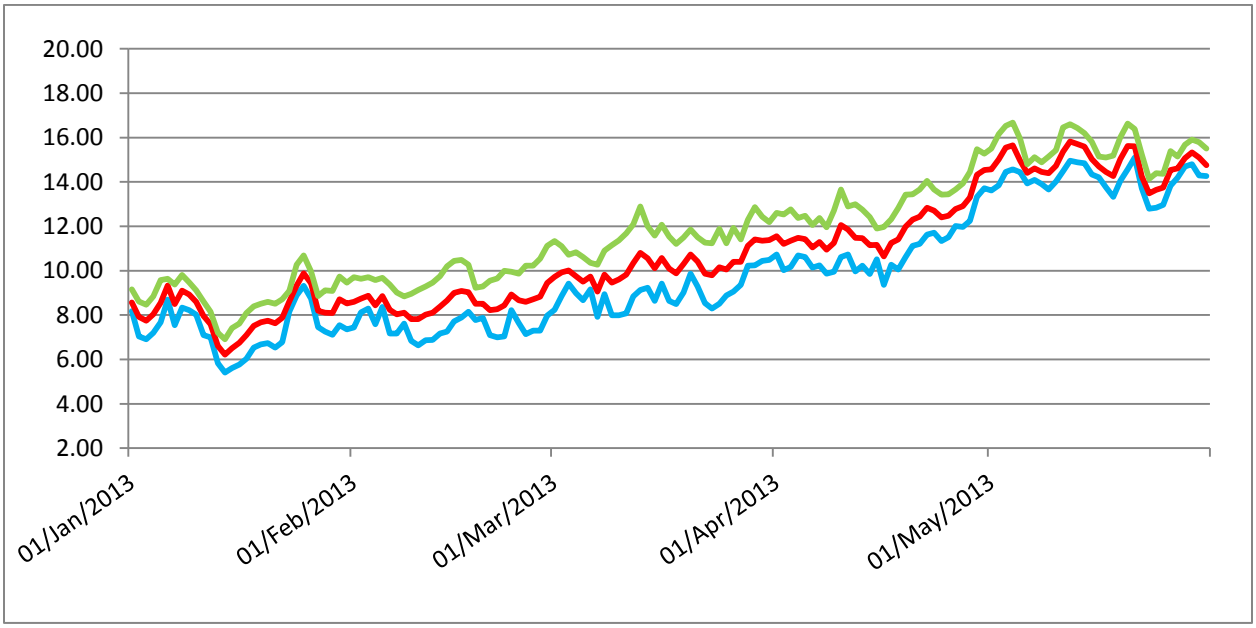
Graph 4b. Average daily water temperature (ºC) collected at McClellen Road (Temperature station # 10290-14) and is depicted on the graph in red from January 1, 2013 through March 31, 2013.Maximum daily temperature is depicted in green and minimum daily temperature in blue. The gap in data collection, February 27-March 14 2013 was due to servicing and refurbishing equipment.



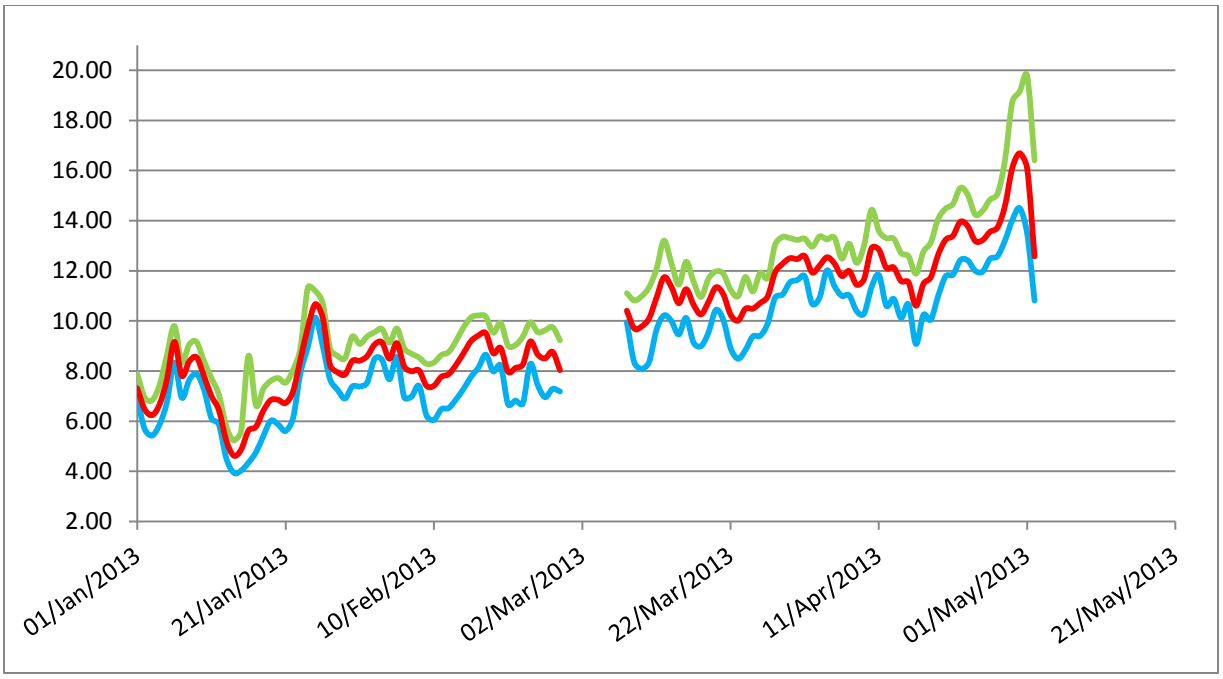
Graph 5b. Average daily water temperature (ºC) collected at Blackberry Farm Park upstream of the golf course (Temperature station # 10290-34) and is depicted on the graph in red from March 8, 2013 through March 31, 2013.Maximum daily temperature is depicted in green and minimum daily temperature in blue.



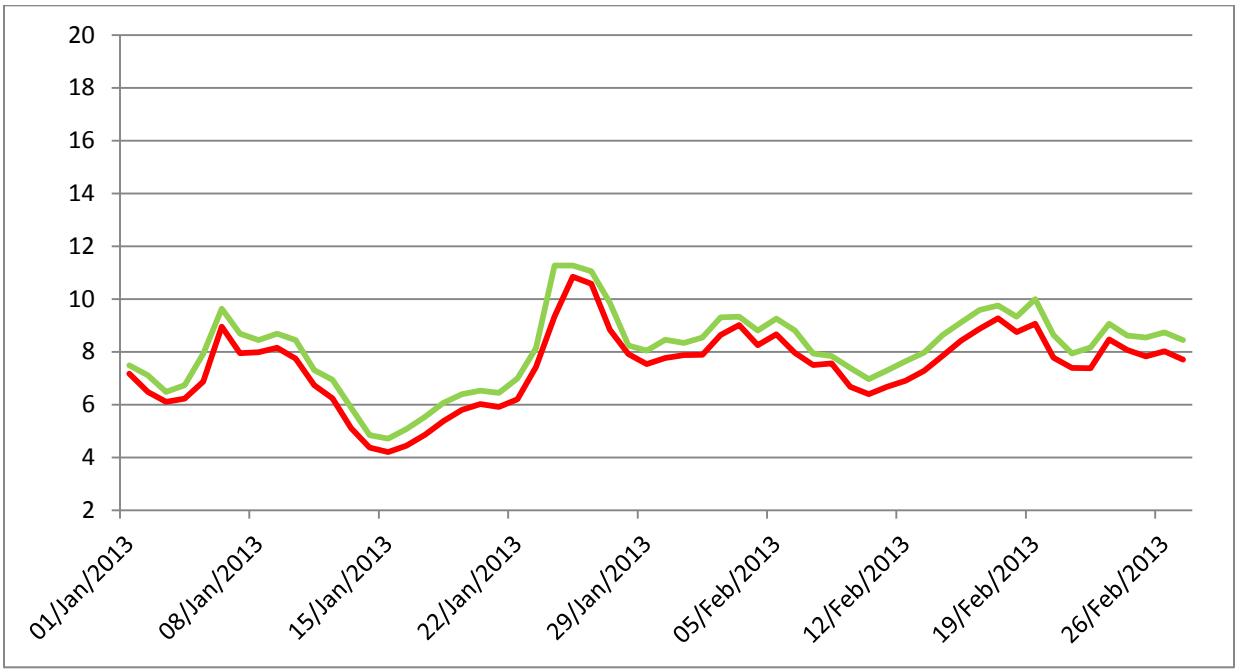
Graph 6b. Average daily water temperature (ºC) collected downstream of Stevens Creek Boulevard (Temperature station # 10290-11) and is depicted on the graph in red from January 1, 2013 through March 31, 2013.Maximum daily temperature is depicted in green and minimum daily temperature in blue.



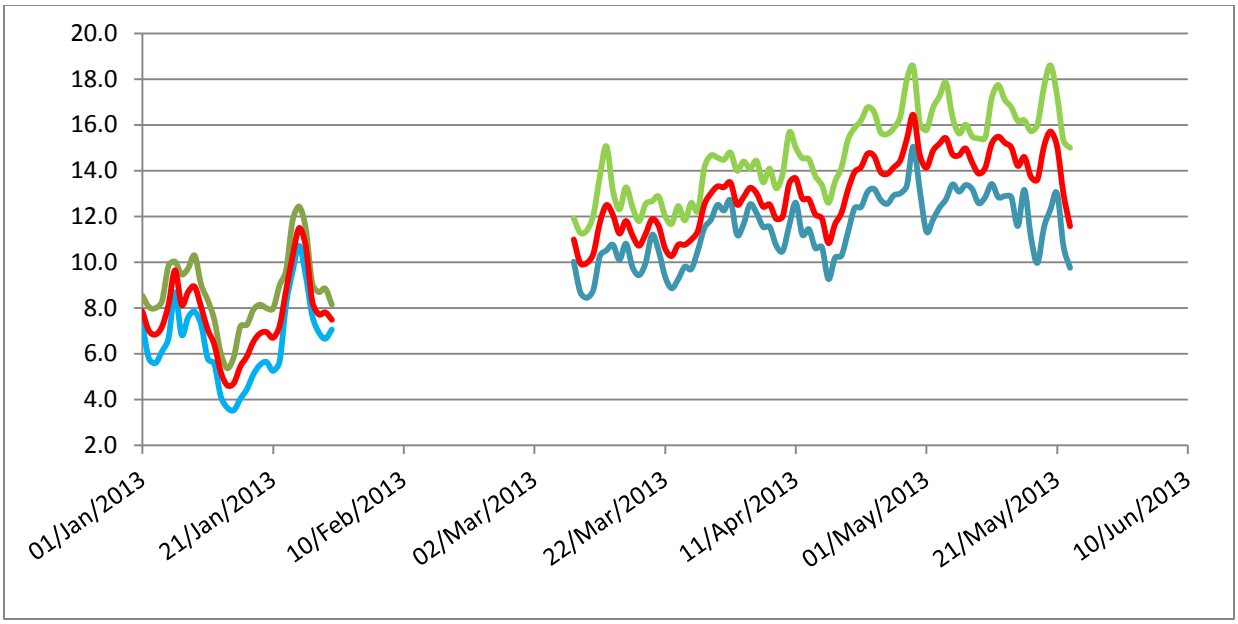
Graph 7b. Average daily water temperature (ºC) collected upstream of Interstate 280 crossing on Stevens Creek (Temperature station # 10290-10) and is depicted on the graph in red from January 1, 2013 through May 31, 2013.Maximum daily temperature is depicted in green and minimum daily temperature in blue.



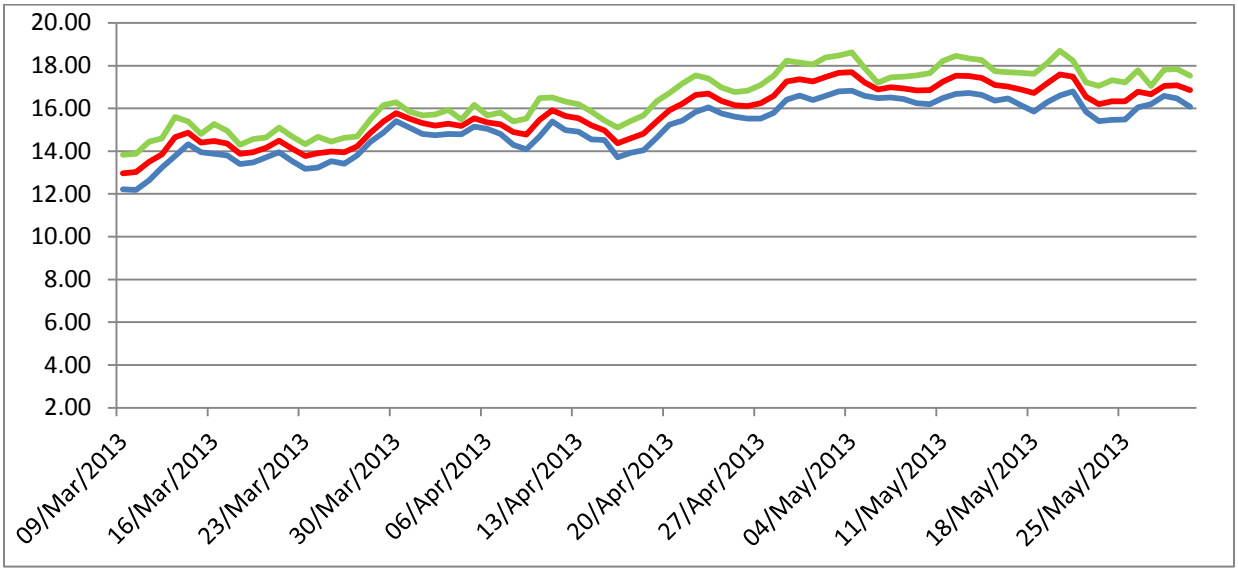
Graph 8b. Average daily water temperature (ºC) collected upstream of Permanente Diversion Channel on Stevens Creek (Temperature station # 10290-35) and is depicted on the graph in red from January 1, 2013 through May 31, 2013.Maximum daily temperature is depicted in green and minimum daily temperature in blue. . The gap in data collection, February 6-March 8 2013 was due to servicing and refurbishing equipment.



Graph 9b. Average daily water temperature (ºC) collected downstream of the Permanente Diversion Channel on Stevens Creek (Temperature station # 10290-27) and is depicted on the graph in red from January 1, 2013 through February 27, 2013.Maximum daily temperature is depicted in green.



Graph 10b. Average daily water temperature (ºC) collected at El Camino Real on Stevens Creek (Temperature station # 10290-01) and is depicted on the graph in red from January 1, 2013 through May 20, 2013.Maximum daily temperature is depicted in green and minimum daily temperature in blue. The gap in data collection, January 30-March 8 2013 was due to servicing and refurbishing equipment.



Graph 11b. Average daily water temperature (ºC) collected in Stevens Creek at Moffett Boulevard at the trap site (Temperature station # 10290-24) and is depicted on the graph in red from March 9, 2013 through May 30, 2013.Maximum daily temperature is depicted in green and minimum daily temperature in blue.